THE UNIVERSITY
of EDINBURGH

This thesis has been submitted in fulfilment of the requirements for a postgraduate degree (e.g. PhD, MPhil, DClinPsychol) at the University of Edinburgh. Please note the following terms and conditions of use:

This work is protected by copyright and other intellectual property rights, which are retained by the thesis author, unless otherwise stated.
A copy can be downloaded for personal non-commercial research or study, without prior permission or charge.
This thesis cannot be reproduced or quoted extensively from without first obtaining permission in writing from the author.
The content must not be changed in any way or sold commercially in any format or medium without the formal permission of the author.
When referring to this work, full bibliographic details including the author, title, awarding institution and date of the thesis must be given.

THE UNIVERSITY
of EDINBURGH

Scottish Space Sector and Innovation

A PERIpatetic study of an emerging innovation system and the roles of innovation intermediaries

Matjaz Vidmar

PhD in Science and Technology Studies
The University of Edinburgh
2019

Declaration

I declare that the thesis has been composed by myself and that the work has not been submitted for any other degree or professional qualification. This study was conceived, developed, carried out and presented solely by me, though some specific conceptual development with relation to "absorptive capacity" was led by Alessandro Rosiello[1].

I confirm that the work submitted is my own, except where work which has formed part of jointly-authored texts has been included. My contribution and those of the other authors to this work have been explicitly indicated below. I confirm that appropriate credit has been given within this thesis where reference has been made to the work of others.

The work contained in this thesis was peer-reviewed and presented at several conferences. The work in Chapter 4 was presented and published in *Proceedings of DRUID 2018* in Copenhagen (June 2018), Chapter 5 was presented and published as part of *Proceedings of the 70th International Astronautical Congress* in Washington (October 2019), D.C and Chapter 7 was presented at *AsSIST-UK National Conference 2019* in Manchester (September 2019).

Some of the chapters were also published in peer-reviewed journals. Chapter 1 was published in New Space (Volume 8, Issue 1). A version of Chapter 2 was presented at *17th Alpe-Adria STS Conference (2018)* in Graz (May 2018) and published in *Space Policy* (Volume 49). A draft Chapter 3 was presented and included in *Proceedings of the 69th International Astronautical Congress* in Bremen (September 2018) as well as subsequently published in *Acta Astronautica* (Volume 167) as a joint publication by Matjaz Vidmar (thesis author) and my supervisors, Alessandro Rosiello, Niki Vermeulen and Robin Williams, and my external mentor, Julian Dines (STFC)[2]. The work in Chapter 6 was presented at *smartEIZ* conference in Zagreb (October 2018) and published in *Croatian Economic Survey* (Volume 21, Issue 2).

The overview of the content and publication status of all papers/chapters is outlined in Table 17 in Appendix A.

Matjaz Vidmar
April 2020

---

[1] This conceptual development was part of an unsuccessful ESRC project bid: "The Role of Absorptive Capacity in Regional Industrial Development: Comparative Multilevel Analysis Across Three UK Regions". The application was co-authored by Alessandro Rosiello (University of Edinburgh Business School), Richard Harrison (University of Edinburgh Business School), Dagmara Weckowska (Business School University of Sussex), Sue Newell (Business School University of Sussex), Piera Morlacchi (Business School University of Sussex), Omid Omidvar (Coventry University Business School), with input from this thesis' author, Matjaz Vidmar, who was proposed to be appointed as research fellow on this project, had it been successful.

[2] This study was conceived by me only, with input from my supervisors, in particular as related to the concept of "absorptive capacity", as per above. I carried out all other theoretical analysis and conceptual development, all methodological development and all of the empirical work, analysis and discussion.

Abstract

This thesis seeks a more effective understanding of Open Innovation (OI) and the available strategies for its development within (geographically–bound) sectoral systems of innovation (GSSIs). Theoretically, it draws upon the competing intellectual traditions (from innovation studies and from science and technology studies) with their different presumptions, which alternatively favour either macro-level positivist or micro-level interpretativist perspectives. These divides prevent a more holistic theoretical understanding of OI, and present a challenge to practitioners, who struggle to operationalise the theories' insights.

Hence, this thesis proposes a novel Practical Epistemology for Researching Innovation, i.e. the PERIpatetic Approach, which aims to integrate multiple theoretical and empirical perspectives for a flexible, problem-driven academic enquiry. This new framework for participatory action research is based on "abductive" theory development, which uses bottom-up empirical engagement to identify emergent challenges to state-of-the-art understanding. The research methodology put forward for this approach is centred on strategic ethnography of innovation, which combines multi-sited mixed-method research design, with constructive embeddedness in the field.

The empirical focus of this thesis is on the emergence of the (New) Space Sector in Scotland - mainly made up of small-to-medium-sized enterprises (SMEs). Here, miniaturisation and cheapening of core technologies and increased access to space data has been driving significant sectoral growth and diversification – which is of interest to entrepreneurs and politicians alike. I approached the field by being embedded within an active intermediary, which wanted to understand and respond to these trends and opportunities. Consequently, this thesis analyses the modelling of OI between macro-level trends and micro-level practices, through a focus on the activities and organisational behaviour of a network of SMEs and opportunities to support them through the work of innovation intermediaries.

In its first part, the thesis analyses the UK/Scottish innovation policy in the Space Sector, exposing the dispersion of public investment, which is creating divergent clusters. These clusters attempt to integrate through the concept of "Agile Space" into a collaborative "Living Laboratory", constructing new markets and developing products. Applying social network analysis and outlining a new concept of innovation moments, I focus on the structures at play within this integrative framing, identifying processes of organisational learning which develop structural absorptive capacity. Thus, I form an integrated multi-level perspective on a (geographically–bound) sectoral system of innovation (MLP-GSSI), which can be applied to other OI contexts and can be adapted for analysing other aspects of complex innovation systems.

In the thesis' second part, the analysis seeks to redress the lack of systemic understanding of the central role of innovation intermediaries, by developing new classification and proto-typology of their interventions. To validate and operationalise this new model, I apply it to the network of innovation intermediaries in the Scottish (New) Space Sector. I further contextualise this insight through a detailed case study of two large investments in innovation intermediation in similarly positioned Space Sectors - examining the tension between business development and R&D support for OI-driven smart specialisation.

Lay Summary

Innovation is increasingly seen as a product of systemic relationships between governmental, research, business and civic groups and organisations. This is related to the notion of ever-greater openness in the processes of innovation, however, our understanding of what shape do these processes take is limited due to divisions between examining the big picture of economic development versus engaging with smaller-scale development of new products within firms. There are further tensions between conflicting approaches, which are alternatively foregrounding attempts at replication of global phenomena or in-depth analysis of social and organisational factors in the local innovation process.

These divides are not only problematic theoretically, as they prevent a more holistic understanding of innovation, but are also challenging for innovation practitioners, who are often struggling to find coherent pathways to operationalise insight from scientific research in this arena. Adopting these challenges through working with the various parties involved in innovation, this thesis is setting out an attempt to bridge these divides and propose a conceptual model, as well as demonstrate its real-world application, for a more integrated understanding of innovation, in particular in small companies and (public) organisations supporting them. This thesis is developing a new approach to research, which advocates close engagement with the studied organisations, a problem-solving enquiry focus and strategic data collection across a multitude of views and roles.

In the first part of the thesis, this study examines the emergence of (New) Space Sector in Scotland, which is linked to both new technologies and better access to existing information from space, as well as opening up the innovation process in firms to include more experts and potential users. I examine how innovation policy impacted the development of dispersed clusters of activities and how new groupings of researchers, businesses and users allow for experimentation with new products and markets. I also analyse in great detail the network of relationships between small companies and their partners and map out how they develop practices and procedures around their innovation processes. Overall, I am proposing to merge the some of the different insights by outlining a combined multi-level systemic perspective of transition towards Open Innovation, noting a critical role played by innovation support organisations, i.e. innovation intermediaries.

In the second part of the thesis, I address the underdevelopment of the systematic understanding of the role of said innovation intermediaries, which I expand upon through a new classification and proto-typology of their activities. In order to apply this new understanding on a concrete example, I used this classification to understand the roles of innovation intermediaries in the Scottish Space Sector. This led to mapping out the roles of enabling, equipping, shaping and moving the development of Scottish Space Sector, which was further compared globally through a case study of two leading investments in innovation intermediation, the Scottish Higgs Centre for Innovation and Slovenian centre of excellence Space.Si.

Acknowledgements

It takes a college to write a PhD – and this research would not be possible without the amazing support and help from a great number of colleagues, family and friends.

To begin with, I am profoundly grateful to my supervisors Dr Alessandro Rosiello, Dr Niki Vermeulen and Prof Robin Williams (University of Edinburgh), as well as my external mentor and research co-host, Dr Julian Dines (Science and Technology Facilities Council, STFC). It was their amazing commitment to supporting me and my progress, especially when I was being difficult, that has inspired me to grow as a student, an academic and a person. I owe to them the amazing experience I have just been through over the past five years.

In addition, I would like to especially remember Prof Wayne Holland (STFC), who served as my technical advisor through most of the PhD, and has been always available for questions and valuable insight. His recent untimely departure has left a gaping hole in the Astronomy and Space Science community, and while his legacy lives on, his disarming smile, endless enthusiasm and encyclopaedic knowledge are sorely missed by all of us, who had the privilege to know him.

In the course of my PhD journey, I have also been lucky to receive extensive support from both my Innovation Caucus internship mentor, Prof Tim Vorley, and project manager, Dr Katy Wing (University of Sheffield), as well as from my Overseas Institutional Visit host, Prof Franc Mali, and Dr Jennie Olofsson (University of Ljubljana). Their contribution to this work goes far beyond the theoretical and empirical challenges they helped me solve.

Keeping an eye on the quality of my work, I thank the editors and anonymous reviewers of the papers I have submitted to conferences and for journal publication. I would particularly like to mention here Dr Ken Davidian (Federal Aviation Authority) and Dr Zoran Aralica (Economic Institute Zagreb), whose both encouragement as well as criticism was instrumental in the improvement of the style and substance of my work.

I would further like to thank a plethora of colleagues from across the University of Edinburgh. Dr Sarah Parry, who first introduced me to STIS via a Skype call; Dr Emma Frow, who steered my interests through a taught MSc programme; and Prof Jane Calvert, who helped me shape my PhD application. I likely would never have embarked on this journey, had it not been for them. Likewise, this research would not be the same without the constructive feedback from my first-year board reviewers, Prof Jamie Fleck and Dr Graham Spinardi. In truth, these pages are too short to mention all colleagues across STIS who have been instrumental in shaping my thinking.

I would like to thank colleagues from other departments, too, who have been generous with their time and insights, in particular, Dr Jacob Copeman (on ethnography), Dr Gil Viry (on Social Network Analysis), Dr Raluca Bunduchi (on firm-level analysis) and Dr Fumi Kitagawa (on regional studies). I would also like to express my thanks to dozens of staff and fellow students providing me with vital food for thought at seminars, lectures and through informal discussions, as well as friendship and support.

I am further deeply grateful to all colleagues at the Royal Observatory Edinburgh (ROE), in particular, the STFC's UK Astronomy Technology Centre (UK ATC)'s past and present Innovations team (Steve Greenland, Ruaridh Henderson, Donald Mcleod, Luke Vanstone, Andy Vick and Karina Wardak), Claire Dougan (STFC Head of Impact Evaluation), UK ATC's management team, the Institute for Astronomy staff (especially Prof Philip Best, Prof Jim Dunlop, Prof Andy Lawrence, Prof Bob Mann and Dr Joe Zuntz) and all my office mates throughout the years. The fact that ROE feels like a home is in no small part due to the amazing people working there.

Most importantly, this research would not be possible without my informants, the fifty or so amazing individuals who took the time to assist me in my enquiries through any of the formal data collection exercises, as well as several hundred others, with whom I spoke informally about my work. I am neither able or allowed to share all your names here, but you may rest assured that I will never forget the help and insight provided by any single one of you.

I would also particularly like to express my thanks to STIS' amazing administrative support staff, in particular, Margaret Acton, Géraldine Debard and Anne Valentine, as well as Phil Symonds from the UK ATC IT team, Jason Cowan from the UK ATC media team, and Saskia Briley from the UK ATC project office. Same goes to the School of Social and Political Science's Graduate School and Student Development offices, College of Arts, Humanities and Social Science office, and the Scottish Graduate School of Social Science (SGSSS) office teams, in particular, Lindsay Hunter, Lorna Shiels, Lucie Stokes and Kirsty Womble. Your patience and kindness pierced through moments of frustration and made all problems solvable.

Finally, the unwavering support from my family and friends has been my rock through all the challenges and successes of this project. Words cannot express my love and admiration for my partner, Julija, who has shown infinite patience in the face of my increasingly obsessive relationship with this work. My mum, Vesna, has been my greatest supporter and my harshest critic. Many colleagues became friends during this journey, especially in STIS, at the ROE, through public engagement and among the Slovenian community in Scotland. The numerous little ways in which you have kept me safe and sound, and have given me love and support, make me feel truly humbled and blessed.

This research has only been possible through the generous studentship from the SGSSS Doctoral Training Partnership, funded by the Economic and Social Research Council (ESRC) [grant number ES/J500136/1]; the SGSSS Overseas Institutional Visit (OIV) Grant; Innovate UK – ESRC 2017 Innovation Caucus internship [funded through ESRC grant number ES/T000570/1]; numerous other small grants and awards (William Dickson Traveling Fund, IAF Emerging Space Leaders Award, ESA International Space Education Board Scholarship, SGAC European Space Leader Award, STIS Travel Funding and Graduate School Office Practice Programme grants); and in-kind support from STFC/ATC Innovations team.

I would also like to express my great appreciation to my examiners, Prof Marina Candi and Prof Andrew Webster, for taking their valuable time to read through these pages and providing thorough and constructive feedback.

I thank you all.

Table of Contents

List of Figures

List of Tables

Key Terms

(Artificial) Satellites are objects in Outer Space orbiting the Earth (or other bodies), which were designed, built and put in orbit by humans.

The **environment** is all external elements of (a person's or) firm's existence, examples being markets, customers, competition, legal framework or regulation, knowledge generation through research, etc. and all that defines the relation of those elements to the company.

Firm or **company** is a business organisation, its people, products and property, which is joined (incorporated) under one name and is involved with economic activity such as design, production and distribution of goods or services.

High-tech or **High Technology** is denoting the fields of the most advanced technological development. This is usually classified on a Sectoral level, depending on the degree of R&D intensity. (Aero)space is listed by OECD as a high-tech sector (OECD, 2011).

Incubation is a support mechanism, provided by a third party, for (young) companies to develop their business model or product/service idea into a viable (self-sustainable) business.

Innovation is the activity leading to a successful implementation of new ideas (Swann, 2009). It can be dominated by either technological advancement through R&D (i.e. "**technology-push**") or addressing a market opportunity (i.e. "**market-pull**"). Those processes, however, can have different effects on the business and its environment (including the market). The more revolutionary, drastic effects are denoted as **radical innovation**, whereas a more evolutionary, "one-step-at-a-time" change is called **incremental innovation**.

An **intermediary** is a person or group/organisation who act as a link between people or other groups/organisations in order to further common interests.

Intervention (tools) are policies, programmes or funding mechanisms, designed to bring about the desired change in the current situation, e.g. growth of a company, successful design of a product, etc.

Knowledge (and its **creation**) is (new) information obtained through the process of research or enquiry. It can be of two main types: **formal** or **codified** (also "**factual**") **knowledge** can be recorded and transmitted independently of the originator's presence, whereas **informal** or **tacit knowledge** (also referred to as "**skills**" or "**know-how"**) is only passed through (prolonged) interaction, often involving "cultivation" in a professional practice. The dissemination or transition of knowledge is also referred to as "**knowledge flow**".

New Product Development (NPD) is the entire process of bringing a new product to the market. This can be split into two related sets of activities:

> **Research and Development (R&D)**: is the technical development of a new product, which includes knowledge/idea generation, technical feasibility studies, product engineering and design, and testing and quality assurance.

Business Development (BD): is about creating value for the company from the new product and includes market research and strategy, construction or adaption of a business model, product launch, and future growth strategy.

A **network** is a type of social institution, which is embodied in relationships and connections among actors (nodes) who form a particular group or community. The actors in a network could be individuals or organisations, for example, companies.

Policy is a course or principle of action adopted or proposed by an organization or individual.

Satellite Applications or **Space Applications** are products or services derived from the use of data or technologies generated by placing artificial objects in Outer Space, such a Satellites. It is commonly broken down into three areas:

Earth Observation is the range of technologies, products and services, which collect information about the Earth from a location in Outer Space.

Satellite Navigation is a range of technologies, products and services, which are aimed to assist with geo-spatially locating and directing users using triangulation of signal from satellites orbiting the Earth.

Space Telecommunications and Broadcasting are two interconnected fields of technologies, products and services, which transmit electronic signals via satellites in outer space.

Small to Medium-sized Enterprise is used here in line with UK legislation to describe a firm with at least two of the following: a turnover of less than £25m, less than 250 employees, and/or gross assets of less than £12.5m.

Spin-out (or **spin-off**) is the process of creating a company on the basis of intellectual property developed as part of academic or applied research within an established firm or a research institution.

Start-up is the process of creating a company on the basis of entrepreneurial activity, mainly for the purpose of addressing a market need.

Acronyms and Abbreviations

ADMS-ILG – Aerospace, Defence, Marine and Security Industry Leadership Group

BBC – British Broadcasting Corporation

BD – Business Development

BIC – Business Incubation Centre

BoAP – Biographies of Artefacts and Practices

CEO – Chief Executive Officer

CERN – European Organisation for Nuclear Research

CoE – Centre of Excellence

CoPS – Complex Products and Services

CTO – Chief Technology Officer

DLR – German Aerospace Centre

DTH - Direct-to-Home (broadcasting/television)

GPS – Global Positioning System

ECSAT – European Centre for Space Applications and Telecommunications

ECOSUR - El Colegio de la Frontera Sur (a university in Mexico)

EO – Earth Observation

EPSRC – Engineering and Physical Science Research Council (UK)

ESA – European Space Agency

ESOC - European Space Operations Centre

ESRC – Economic and Social Research Council (UK)

ESTEC - European Space Research and Technology Centre

EU – European Union

GLIC - Global Space Innovation Conference

GLIS - Global Conference on Space and the Information Society

GNSS – Global Navigation Satellite System

GPS – Global Positioning System

GSSI – Geographically-bound Sectoral Systems of Innovation

IAC – International Astronautical Congress

ICT – Information and Communication Technologies

IGS – Innovation Growth Strategy

INPE - National Institute for Space Research (Brazil)

IP – Intellectual Property

IS – Innovation Studies

IT – Information Technology

JAXA – Japanese Aerospace Exploration Agency

MLP – Multi-Level Perspective

NASA – National Aeronautics and Space Administration (US)

NERC – Natural Environment Research Council (UK)

NOAA – National Oceanic and Atmospheric Administration (US)

NPD – New Product Development

NUTS – Nomenclature of Territorial Units for Statistics

OECD – Organisation for Economic Co-operation and Development

OHB - Otto Hydraulic Bremen (Germany)

OI – Open Innovation

OIV – Overseas Institutional Visit

R&D – Research and Development

ROE – Royal Observatory Edinburgh

S3 – Smart Specialisation Strategy

SE – Scottish Enterprise

SGSSS – Scottish Graduate School in Social Science

SME – Small to Medium-sized Enterprise

SNA – Social Network Analysis

SNS -Space Network Scotland

SoXA – Scottish Centre of Excellence in Satellite Applications

Space IGS – Space Innovation and Growth Strategy

SPIE – International Society for Optics and Photonics

SSI – Sectoral Systems of Innovation

SSTL – Surrey Satellite Technologies

STFC – Science and Technology Facilities Council (UK)

STIS – Science, Technology and Innovation Studies

STS – Science and Technology Studies

STSKT - Socio-Technical System of Knowledge and Technologies

STA - Socio-Technical Assemblage

SUPA – Scottish Universities Physics Alliance

UK – United Kingdom

UK ATC (or ATC) – UK Astronomy Technology Centre

UN – United Nations

US(A) – United States (of America)

USP – Unique Selling Point

PREFACE

Introduction

This thesis contains a portfolio of papers written as part of a cross-field enquiry in the development of the Space Sector in Scotland, examining the innovation policy, inter-organisational practices, innovation networks and processes, and the central role of innovation intermediaries' interventions. Each chapter was written as a stand-alone article in its own right, and each was tested and improved through conference and journal peer-review process[3]. Consequently, the research questions, engagement with literature as well as research methods are presented throughout the thesis, rather than being grouped at the front. There are also some small differences in structure and layout styles, as these reflect requirements by the journals where individual chapters have been published.

Overall, the research presented within these papers was driven by a mixture of practitioners' concerns and my ambition to systematise and integrate the state-of-the-art insights and methodologies into a coherent set of tools and practices for studying intra-organisational features of innovation. Specifically, the advent of "New Space", an industry transition characterised as a market expansion on the back of increasing access to core technology and data outputs, has exposed questions about the adoption of new (inter-)organisational practices and formation of innovation networks, which are supporting increasing "openness" of innovation processes in small-to-medium-sized enterprises (SMEs). In particular, this thesis explores the understanding of Open Innovation transition (Chesbrough, 2003) through Multi-Level Perspective (Geels, 2002) and (Sectoral) Innovation Systems (Freeman, 1991; Breschi and Malerba, 1997) models, especially as applied to SMEs and the role played by Innovation Intermediaries.

Though "openness" has been a critical interest in the development of science and advancement in technology, a lot of the more detailed understanding of the mechanics of the (cultural) changes it relates to in organisations has been rooted in context of large-scale corporations of the industrial and post-industrial era (Parida, Westerberg and Frishammar, 2012; Hossain and Kauranen, 2016). In contrast, the current economic system relies

[3] An overview of the chapters' content and their presentation and publication strategy are presented in Table 17 in Appendix A.

significantly on “bottom-up” innovation from small-to-medium-sized enterprises (SMEs), working in a closely-linked innovation (eco)system with academic research organisations, regulators and government, and (lead) customers and users. This model has been described as the “triple helix” (Leydesdorff and Etzkowitz, 1995) and has recently become a leading interest within research in support for Open Innovation, in particular through the interconnecting role of innovation intermediaries (Kerry and Danson, 2016), though the understanding of the intermediaries was noted to require significant systematisation and operationalisation (Hannon, Skea and Rhodes, 2014).

However, there have long been significant tensions between near dichotomous research focus on either intra-organisational innovation processes or on inter-organisational networks and systems (Green *et al.*, 1999). This split was further confounded by the competing intellectual traditions of macro-level positivistic approaches within innovation studies (IS) and micro-level interpretivist perspectives within science and technology studies (STS) (Williams and Velasco, 2016). One attempt at bridging these divides was the proposed integration of IS’ Sectoral Systems of Innovation (SSI) theory with the Multi-Level Perspective (MLP) on innovation transitions (Geels, 2004). However, due to conceptual misalignment, this attempt at developing a more comprehensive framework was largely rejected by IS scholars (on the grounds it misunderstands SSI), and the resulting relational complexity led to low engagement from STS researchers.

In this thesis, I make another attempt at reconciling these opposing approaches by re-aligning the corresponding concepts and proposing multi-perspective and multi-level linkages. In particular, using integrative epistemological principles of integral dialectics (Shirazi, 2015), the opposing positivist and interpretivist approaches are shown to have complementary strengths and weaknesses, and can support each other. That is particularly true of the SSI’s issues with lack of theoretical depth and coherence and conversely MLP’s lack of conceptual clarity. By aligning SSI’s clear conceptual framework to MLP elements’ definitions (as well as clarifying its geographical boundedness) and thus enabling the adoption of MLP’s explanatory power in understanding system transitions, I proposed a critical contribution to knowledge in the form of a combined MLP-GSSI model. This was complemented by applying and examining these elements in empirical work in the field.

In particular, I grounded my research geographically in Scotland, as its territorial size and socio-economic and political characteristics make it a very well-proportioned and coherent empirical sample, which meant that I was able to develop a comprehensive data collection strategy. Sectorally, I examined a network of high-tech SMEs within the Space Industry, where a transition to Open Innovation occurred within the context of an emergent "New Space" industry segment. Specifically, advances in electronics' miniaturisation and open access to data democratised access to this sector for new, smaller players more reliant on systemically interrelated innovation processes including external players. Temporally, the empirical research is situated between 2014-2017 (with data collected on events going as far back as the early 2000s), during which time this transition in Scotland was at its mid-point (there was an almost equal number of previous generation players, as the "new space" ones).

In addition, due to the close collaboration with key stakeholders in the Scottish Space sector, I developed a novel research practice by devising the framework of the PERIpatetic Approach. The double-meaning of PERI acronym comprise both the Practical Epistemology for Researching Innovation as well as the principles of Perspectival, Embedded, Reflexive and Introspective take on methodology, ontology, epistemology and ethics; based on participatory action research, critical realism and abductive epistemology (a more detailed and reflexive account of this approach can be found in Chapter 8).

In the rest of this chapter, I go in further depth on my research aims and knowledge gaps, as well as outline my research design, before presenting the thesis' chapters outline.

Research Aim and Knowledge Gaps

Research Aim

Building from the extensive interaction with practitioners outlined above, a set of critical questions emerged about the environment I was taking part in. Specifically, these revolved around three strands of enquiry – How is the Scottish Space Sector formed? What can innovation intermediaries do to support it? How can the best insights and be developed and applied (in research and in practice)? Hence, my research aim became centred on an ambition to develop an **understanding of the mechanics of inter-organisational practices of steering innovation networks and processes between/within SMEs**, and **the interventions, which innovation intermediaries can deploy to assist in such endeavours**. Having pre-selected the empirical field, there were also specific questions related to the emerging geographically-bounded sectoral system of innovation, i.e. the high-tech Space Sector in

Scotland. True to these questions, my intellectual journey led to three main areas of theoretical development: the integration of systemic and multi-level approaches to modelling innovation, designing a holistic approach to frame innovation intermediaries interventions and developing the PERIpatetic philosophical position.

Knowledge Gaps

There persists an acute lack of integration of the current (micro-level) literature on innovation process (Swann, 2009), the (meso-level) literature on (regional and sectoral) Innovation Systems (Malerba, 2006) and capacity building within the (macro-level) innovation policy context (Flanagan, Uyarra and Laranja, 2011). In particular, it was posed that a paradigm shift occurred through the conceptualisation of Open Innovation, i.e. the notion that innovation processes cross-organisational/firm boundaries (Chesbrough, 2003). However, how micro-level organisational behaviours, meso-level inter-organisational interaction and macro-level policy interventions and support link together is less clear (Lee *et al.*, 2010; Chesbrough and Bogers, 2014; West *et al.*, 2014). The particular emerging concern is the notion of "transition" towards Open Innovation, i.e. how do organisations adopt/change these processes (from meso- to micro- level) and how are the individual changes built upon a systemic level (meso to macro and the reverse)? These questions are especially pertinent in the context of the small-to-medium-sized enterprises (SMEs), who form a significant part of the innovation landscape and are becoming the focus of innovation policy in many countries, including the UK (Bodas Freitas and von Tunzelmann, 2008; Chesbrough and Vanhaverbeke, 2011; Cooke, 2012; Doh and Kim, 2014; Love and Roper, 2015).

I argue that two sets of approaches can be deployed to address these gaps in understanding the "translation" of Open Innovation from policy to practice.

On one hand, perhaps the most widely applied current framework derived from the Innovation Studies is the Innovation Systems approach (Freeman, 1991), which branched out to examine both geographical (Nelson, 1993; Cooke, 2001) as well as sectoral/technological dynamics (Breschi and Malerba, 1997; Bergek *et al.*, 2008). In this thesis, a critical integration of these two branches of studies is proposed as geographically-bound sectoral systems of innovation (GSSI), building on previous observations of the synergic multiplicity of such boundaries by Edquist (2001). In addition, multi-level perspective on innovation transitions has been proposed in Science and Technology Studies (STS), chiefly by Geels (Geels, 2002, 2005), which sought to contextualise the empirically derived systemic insights with the more structured sociological theories of change. Explicit attempts were made to link the two frameworks together (Geels, 2004; Markard and Truffer, 2008), though a degree of conceptual misalignment led to much resistance.

On the other hand, a lot of interest has been expressed in understanding the role of intermediary in supporting innovation processes and systems (Duff, 1996; Green *et al.*, 1999; Smits and Kuhlmann, 2004; Dosi *et al.*, 2006; Ngwenya and Hagmann, 2011). In fact, a significant body of literature has emerged about innovation intermediation (Howells, 2006), with specific reference to Open Innovation (Chesbrough, 2006; Antikaninen, Mäkipää and Ahonen, 2009; Katzy *et al.*, 2013; Kokshagina and Masson, 2015) and Innovation Systems (Nilsson and Sia-Ljungström, 2013; Klerkx, Álvarez and Campusano, 2015; Kerry and Danson, 2016). However, though many attempts at systematising the extensive empirical studies were made (Dalziel, 2010; Kilelu *et al.*, 2011; Kivimaa, 2014; Kim, 2015; Klerkx, Álvarez and Campusano, 2015; Lukkarinen *et al.*, 2018), the dividing lines between intermediaries supply of resources versus engaging in direct activities, close involvement versus systemic provision and providing physical interventions versus deploying social capital were seldom crossed. Hence most of the emerging classifications and typologies were incomplete and their operationalisation in practice hindered by an acute lack of clarity.

These gaps in this body of knowledge were also previously directly and indirectly pointed out in a variety of literature:

- there was so far only a cursory analysis of the transition in the New Space sector available (Adlen, 2011; Space IGS, 2011)
- there is a particular interest in better understanding technology development in the (New) Space Sector (Petroni and Verbano, 2000; Comstock and Lockney, 2007; Petroni *et al.*, 2013; Venturini and Verbano, 2014)
- there are unanswered questions regarding innovation network development in emergent sectors (Human and Provan, 2000; Pittaway *et al.*, 2004; Powell, 2005; Provan, Fish and Sydow, 2007; Valkokari and Helander, 2007; Simard, 2015)
- the Open Innovation practices in SMEs thorough network mediated processes are not well understood (Brüderl and Preisendörfer, 1998; Lee *et al.*, 2010)

- there is an acute lack of systemic integration of the understanding of the roles of innovation intermediaries (Smits and Kuhlmann, 2004; Klerkx and Leeuwis, 2008; Dahlander and Gann, 2010; Katzy *et al.*, 2013; Hannon, Skea and Rhodes, 2014)
- there was limited linking micro- and macro- innovation literature by meso-level (network) studies (Green *et al.*, 1999; Edwards, Delbridge and Munday, 2005; Malerba, 2006; Ngwenya and Hagmann, 2011)
- there is an overall lack of integration of science and technology studies and innovation studies perspectives (Geels, 2004; Martin, 2016; Williams and Velasco, 2016; Williams, 2019)

The specified research aim and the identified gaps in the literature have led me to attempt to develop as comprehensive an assessment as possible of an emerging technology sector based on regional know-how, political ambition, global trends and specific industry culture. This is a much-needed study as it is addressing a set of key contemporary concerns:

- adopting a relatively novel and radical research philosophy and practice
- there are no previous comprehensive studies of the Scottish (New) Space Sector
- there are no previous comprehensive studies of SME innovation in the context of the transition to the 3rd generation Space Sector ("New Space")
- there are no previous joined up studies of inter-organisational network structures and analysis for an emerging high-tech sector
- there are many dispersed and fragmented models of innovation intermediation, with lack of analytical and operational clarity

As theory development was an iterative process dispersed throughout the work presented in the chapters/papers in this thesis, the conceptual framework is fully drawn out in the Conclusions chapter.

Research Design

Research Collaboration with UK ATC Innovations Team

The research design adopted to engage with these concerns has somewhat of a novel framing in of itself, with a multi-dimensional research approach, built upon the principles of science and technology studies. In particular, my engagement with the field was developed on the back of my pre-existing familiarity with Astrophysics research in Scotland, through my first degree, and my close links and significant interest in the work carried out at the Royal Observatory Edinburgh (ROE). This historical Scottish institution is still at the forefront of global science and technology development for Space Science, through the work of the Institute of Astronomy, part of The University of Edinburgh, and the UK Astronomy Technology Centre (UK ATC), national laboratory for astronomy and space instrumentation run by the Science and Technology Facilities Council (STFC). It was their desire for furthering the impact of this work, which led to the creation of the Higgs Centre for Innovation, a new technology/knowledge transfer and business development facility at the ROE campus. In particular, the lack of theoretical and practical understanding of the key mechanisms to deliver the impact desired of this project is the key driver of my research.

Specifically, the development of the Higgs Centre for Innovation rested with the small UK ATC Innovations team, led by Dr Julian Dines. My informal discussions with Dr Dines and his team led to the establishment of a research partnership. The scope of the partnership covered the support provided by UK ATC Innovation, though there were no formal expectations placed on the researcher, beyond the exploration of the critical questions of how is the Scottish Space Sector developing and what would be the most beneficial intervention innovation intermediaries could deploy in support of the sector. Based on this partnership, I became embedded in the UK ATC's Innovation team, who were my main gatekeepers. This meant I was physically co-located (desk-space, IT support, etc.), and have participated in their meetings, helped organise and deliver their activities and attended third-party events (conferences, meetings, etc.) as part of their delegation.

This enabled significantly easier access to the field as well as led to the direct and tangible application of my findings – in particular, the critical contribution to knowledge through a systematisation of literature on innovation intermediation by focusing on interventions (instead of functions) and developing a more comprehensive classification and typology of roles. In addition, my interaction with colleagues at the UK ATC Innovation meant that I was consulted on a variety of state-of-the-art social science insights. For instance, I helped developing a reference library in innovation management literature for use in the Higgs Centre for Innovation, supported a Horizon 2020 research project they were involved with, as well as providing input into various discussions.

Developing the PERIpatetic Approach

This close engagement also required a thorough examination of my scientific method and researcher positionality. In particular, it meant that the framing of my research gives slight precedence to engaging with the field rather than deductive hypostatisation. Specifically, building on my personal experience in the field I developed the Practical Epistemology for Researching Innovation, which I termed as the PERIpatetic Approach. Its conceptual origins come from the ancient Greek schools of Philosophy, where some lead thinkers (in particular Aristotle) have developed their thoughts by "walking about" and speaking with their followers. In fact, the word "peripatetic" itself is derived from ancient Greek, directly merging the meanings of the walking or treading ("patetic") with "going about" ("peri"). The "peri" prefix is being widely used in astronomical terms for orbiting bodies, such as the "perihelion", the closest approach to the Sun. Hence, there were perhaps multiple reasons for Charles Piazzi Smyth, the 2nd Astronomer Royal for Scotland and a pioneer of overseas mountain-top astronomy, to be nicknamed by one of his biographers the "Peripatetic Astronomer".

Though I have only settled on the term at the time of writing up my thesis, I believe the "peripatetic" nature of this project was a vital part of my intellectual journey and its analysis is a significant contribution to knowledge. As a peripatetic researcher, I developed my enquiry around critical issues of the time and approaching them with an open mind and an arsenal of varied (theoretical and methodological) tools, frequently crossing disciplinary boundaries. In particular, the research presented in this thesis was based on being closely embedded within an innovations team at the UK Astronomy Technology Centre and then "moving about" the various sites of interest for the developing the knowledge and technology transfer and application in the nascent (New) Space Sector in Scotland. This was of significant benefit to my project, as my embeddedness into the said (well-connected) team and their wider organisation (STFC) afforded me extensive access to the field, i.e. they became my gatekeepers. Furthermore, the implementation of my findings at the Higgs Centre, enabled my research to have a direct impact on the development of the studied environment and a wide dissemination reach.The PERIpatetic Approach outlines a comprehensive philosophical position is based both on the multi-perspectival methodology (Pollock and Williams, 2010), as well as embeddedness in the field through participatory action research (McIntyre, 2007). Such close-quarters research is responsive to the studied environment through abductive epistemology (Blaikie, 2004) and requires careful introspection through academic and field-based feedback mechanisms. Its inherent peripatetic form is both necessary to address the bottom-up identification of research questions, as well as developing holistic insights to answer them, as participation in the field is a pre-requisite for abductive epistemology, whilst its generalisation and validity can only stem from a (multi-)perspectival methodology and careful researcher positioning. In the course of my research, I proposed new (theoretical) clarity on these framings, in particular by developing the participatory strategic ethnography of innovation methodology and analyse my positioning in the field as an "uninformed insider". The former was inspired by the Biographies of Artefacts and Practices Approach (BoAP) (Williams and Pollock, 2012), whilst the latter is a response to a previously established "informed outsider" position (Welch *et al.*, 2002). (More details on this are in Chapter 8.)

Research Timing

The bottom-up PERIpatetic Approach allowed me to map out the make-up and development of the studied socio-economic landscape and identify its key challenges, which I subsequently empirically and theoretically explored. For instance, the increasing (political) emphasis on technology/knowledge transfer and commercialisation of scientific research is a very contemporary concern (Nutley, Walter and Davies, 2007). Through my PERIpatetic engagement with the field, I established that there is an additional resonance to the changes this new objective brought about within the Astronomy community. Specifically, the traditional sources of societal prestige, in particular, the critical societal role of time-keeping, have gradually disappeared over the 20th century and the community is required to (re-)legitimise the public investment in Astronomy through other means. At the same time, the expanding space industry is now reaching far from its "traditional" locales of superpowers (during the early part of Cold War) and multinational corporations (in the last quarter of 20th century), towards the wider "Western periphery", in particular, countries like Scotland. This is, on one hand, democratising the global Space Sector (in particular through cheapening of hardware and increasing open access to satellite data), whilst on the other hand, creating complex social, economic and political tensions, between academia, businesses and governments and public organisations. These tensions are in particular related to the need for increased openness and collaboration, which is often met by a lack of understanding of the partners' interests, organisation culture and the wider environment.

The increasing recognition of these challenges is helpful for conducting new research, both in terms of there being a significant appetite for collaboration from different stakeholders, an increased openness (due to perceived benefits), and a generation of a significant amount of documents and data. Combining this with a particular empirical focus on Scotland provides a well-proportioned example of an emerging highly innovative high-tech sector within which both system-level understanding as well as individual case studies can be formed.

Research Programme and Timeframe

A detailed summary of the research programme and timeline is presented in Table 18 in Appendix B and outlined in Figure 1 to the right.

In short, Phase 0 of this project (within the MSc year), concerned the framing of enquiry and a research pilot. It involved an extensive review of the existing literature, proposing a theoretical and methodological framework, an in-depth analysis of the subject-matter, and designing and evaluating a data collection strategy. This was then reviewed, revised and updated through the first year of the PhD project (Phase 1). In the third stage (Phase 2), I rolled out data collection across the entirety of active SMEs within the Scottish Space Sector at the time (by the end of 2017, in total just under 20 firms). Subsequently, I undertook a detailed literature

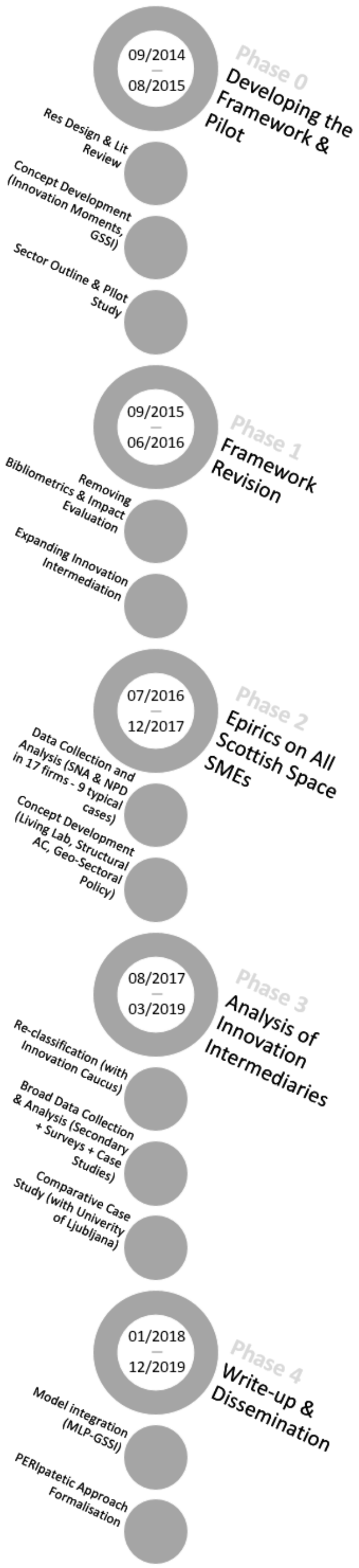


Figure 1 - Summary of the research timeline including the five phases (0-4).

systematisation and empirical research to develop a substantial new understanding of innovation intermediation and its structural position within an innovation system, in particular by examining all such organisations in the Scottish Space Sector through a mix of methods (Phase 3). I also won a three-month internship with Innovation Caucus, an ESRC and Innovate UK funded network run by the University of Sheffield, through which I fine-tuned my conceptual framing of the innovation intermediaries' interventions and the proposed classification and proto-typology working with Innovate UK's leading innovation policy-makers. Lastly, in Phase 4, I developed and disseminated the key finding with respect to the context of local, sectoral and global (innovation) environment.

The timeline for the development of the Higgs Centre for Innovation seemed to coincide perfectly with my project's timeline (though the centre was planned to launch in early 2017, though it was delayed to mid-2018, that was still within the proposed project timeline).

Empirical Methods

This research project is based on a mixed-methods empirical work, as is fast becoming the norm in innovation studies (Harrison, 2013). Overall, I collected the data in three main ways, as is expanded upon further in methodological discussions of each chapter and summarised in Appendix B:

- I analysed secondary data (Bowen, 2009) from published documents, in particular, policy and strategy whitepapers and industry analysis (including econometric data), as well as companies and innovation intermediaries' websites and published impact reports and case studies. Most of this is used to illustrate the development of the Scottish Space Sector in Chapters 1 and 2, and the analysis of innovation intermediaries' interventions in Chapters 5 and 6.
- I conducted informal ethnography (Estalella and Sánchez-Criado, 2015) through participating at a variety of industry events and visited key spaces, specifically attending over 45 conferences and site visits, as well as engaging extensively in sector development initiatives (networks, groups and projects). This informs the background to all the work, but is most explicitly used in Chapters 1 and 2.
- I designed and carried out extensive direct primary data collection (Bryman, 2016), in particular, six scoping interviews (0.5-1h) with selected stakeholders (see questionnaire in Appendix C), 17 detailed SME/company interviews (~1.5h) (questionnaire in Appendix D), innovation intermediaries survey (Appendix F), and

two in-depth innovation intermediaries interviews (1h). All of these were voice-recorded, though critical information from SME interviews was extracted from a data-matrix (see Appendix E), which was filled during the interviews. The scoping data was used in chapters 1, 2 and 6; SME/companies interview data was used in Chapters 2, 3 and 5 and intermediaries survey data was used in Chapters 5 and 6.

The overarching objective of this research is to expose the structural dynamics rather than to describe the nuances of phenomena. Hence, the main triangulation mechanism deployed are comparative case studies and narrative trend analysis. In particular, the data was analysed in four ways:

- I used triangulated qualitative landscape mapping and narrative analysis tools (Mello, 2002) to explore the emerging trends and prevailing opinions of the leaders in the Scottish Space Sector, both in SMEs as well as in innovation intermediaries and related stakeholders (in scoping studies).
- I used quantitative ego-centric Social Network Analysis (Crossley *et al.*, 2015) to analyse the innovation networks of core SMEs within the Scottish Space Sector, as well as subsequently developing a method to construct a consolidated whole socio-centric SNA map (highlighting the role of innovation intermediaries).
- I developed a series of case studies (Yin, 2009) to illustrate the micro-level origins of the structural features examined by this thesis, specifically, the analysis of the organisational behaviour linking innovation network characteristics and the structure new product development process, as well as the features of key innovation intermediaries interventions.
- I have also done a very small-scale quantitative/statistical analysis (Bryman, 2016) of the (innovation intermediaries) survey data.

The structural focus of the data analysis was also aligned with the need to protect the confidential information shared with me by firms and support organisations. Only in some cases, in particular the background analysis based on scoping interviews with a range of stakeholders, direct quotes were used to illustrate the prevailing thoughts amongst the community. The full breakdown of the use of empirical data, analytical methods and triangulation mechanisms used is outlined in Table 22, in Appendix B.

Additional Engagement with the Field

With the core ambition of reflexively engaging with this industry, I also participated in many groups and organisations and led the formation of new networks and projects. As such, on top of my academic research on the aspects of innovation, I participated in the development of the Space sector, through key international R&D, business and social development initiatives. In particular, I tried to influence the development of Space capabilities in my home country Slovenia, which recently became an Associated Member State of the European Space Agency (ESA). There, I engaged with both mapping out the state of progress in the development of Slovenian Space Sector (a joint project with the University of Ljubljana), as well as developed a series of events with the Slovenian Science Foundation, as part of the annual science festival and wider. In particular, working with colleagues in Slovenia alerted me to an excellent opportunity for a comparative case study between flagship innovation intermediaries in the two countries – the Scottish Higgs Centre for Innovation and the Slovenian centre for excellence Space.Si.

In addition, I also worked closely with Slovenia-based and ESA-backed Cultural Centre for European Space Technology and several other research, business and public engagement organisations. For example, as the National Point of Contact for Slovenia at the Space Generation Advisory Council I started a programme of social activities and project to connect the space people in Slovenia and the wider region. This enabled me to uniquely access the high-level policy debates about the development of the global space sector, as well as allowed for the dissemination of the results of my research directly to key stakeholders (in particular space agencies).

As part of these endeavours, and since there seemed to be an acute lack of integration of disciplinary perspectives, I co-founded two interdisciplinary research networks – the global STIS' take on Social Studies of Outer Space (SSOS) and the local (pan-Scottish) Social Dimensions of Outer Space (SDOS) network, which includes interdisciplinary researchers from various fields beyond STIS. This engagement critically illuminated the near-dichotomous split between STS-led ethnographic take on innovation and technology development and the IS-driven econometric and bibliometric one. Attempts at more extensive interdisciplinary perspectives, such as deploying mixed-methods social-network analysis (SNA), led me to experiment with these methods myself, as well as co-coordinating the Social Network Analysis Scotland group to share ideas, new practices and results.

Conversely, through SDOS we published *Scotland in Space* edited volume exploring the future of Space Exploration using science fiction and hosted the Space Enlightenment Festival to celebrate various anniversaries of 2019. Through a series of such developments, the theme of integration emerged as a cornerstone of this thesis as both in my intellectual/analytical as well as participatory/activist journey integration of perspectives, theories, projects, strategies was the leading effort towards a comprehensive and structured understanding of the studied phenomena, leading to both exciting new theoretical frameworks, as well as their practical application.

Thesis Outline

As noted earlier, the thesis chapters are structured as a series of papers – each standing on their own, as well as threading the overarching narrative of my research. They were all presented at national and international conferences and events and subsequently prepared for publication in leading industry and academic journals (see Appendix A). This enabled me to constantly and dynamically address feedback from the peer-review process, as well as respond to practitioners concerns and influencing the development of these fields as my empirical findings, models and theoretical conclusions were disseminated.

As drawn out in Figure 2 in the second-next page, the thesis structure links the chapters (titles in boxes, numbered in thesis' order) according to the three main theoretical areas (multi-level perspective on innovation systems; innovation intermediation; and PERIpatetic approach), each anchored by one of the three main theoretical chapters (double-lined boxes; chapters 4, 7 and 8). It also outlines research pathways, from initial prompt questions (in blue speech balloons) through theoretical and empirical work (full-line arrows), and resulting follow-on questions (dashed-line arrows), which get answered in subsequent chapters. The three "anchor" chapters propose the conceptual frameworks and contain the major theoretical contributions to the body of knowledge examined in my research, each attempting to answer one of the abductively derived research questions.

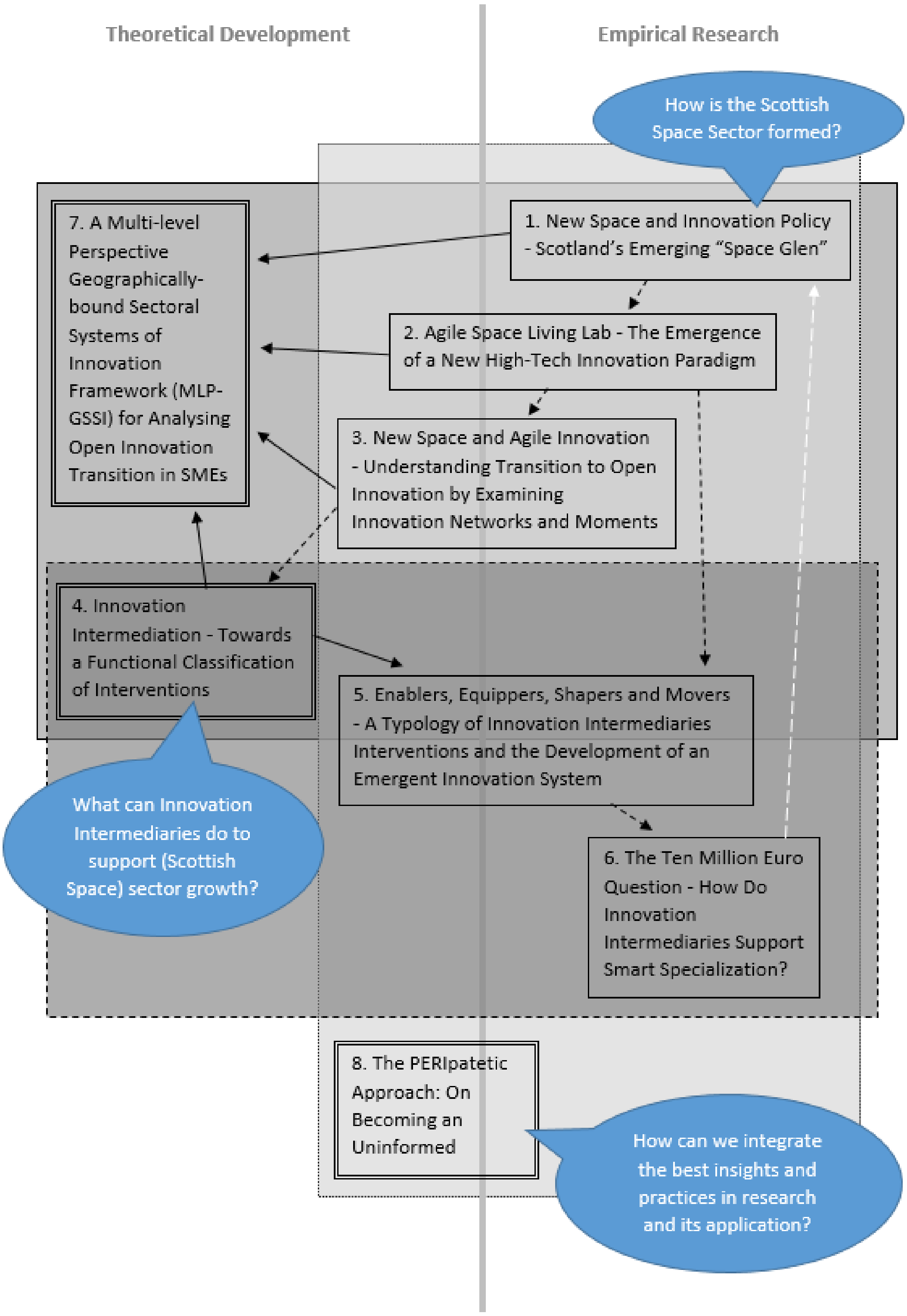


Figure 2 - Conceptual thesis layout through chapters (text boxes; noting chapter numbers) with in initial prompt questions (blue bubbles), three thematic fields (grey squares), anchor theoretical papers (double-lined boxes) and relationships (dash-line arrows for questions emerging, full-line arrows for theoretical contributions).

This empirical work is presented in two main parts. The first part (made of three papers) contains the detailed account of the dynamics of innovation policy (Chapter 1), new practices (Chapter 2) and network and process development (Chapter 3) within the community of the Scottish Space Sector SMEs – noting the central role of innovation intermediaries. The second part (also made of three papers) picks up on this crucial finding and proposes a systematisation of the understanding of innovation intermediaries interventions (Chapter 4), before entering into an extensive empirical analysis of the development of such interventions in the Scottish Space Sector (Chapter 5) and an in-depth comparative study of two leading investments in the sector in Scotland and a similar context in Slovenia (Chapter 6). In the subsequent discussion (two papers), I first develop the combined insight across this thesis and propose a vital integration of multi-level perspective approach with the innovation systems models (Chapter 7), and secondly, I outline a comprehensive analysis of the transformational epistemological, methodological and ethical experiences of my research design (Chapter 8). In conclusion, I sum up the main points of the thesis, discuss contributions and limitations of this project and propose some avenues for complementary and further research.

In the next sections, I outline in more detail the contribution of each chapter as well as the links between them.

Part 1 – The Emergent New Space Sector in Scotland

Chapter 1: New Space and Innovation Policy - Scotland's Emerging "Space Glen"

This introductory chapter outlines the global Space Industry's transition to New Space – i.e. smaller and cheaper hardware and more easily accessible space data – which is expanding space-related economic activity into new, peripheral geographical areas. This paradigm shift has been particularly successful in establishing a budding ecosystem of SMEs in Scotland, which is sometimes referred to as the "Space Glen". These developments are linked to the UK and Scottish policymakers addressing the growth of the Space Sector within the innovation policy, rather than a separate Space policy/programme. I propose that the resulting small-scale and dispersed investment in R&D and business development put forward by the various governmental actors, led to the creation of dispersed and divergent clusters of firms, strongly linked to research expertise at local universities, as well as other sectors with more mature markets, such as oil and gas and forestry. However, recently these are being joined together in a common regional sectoral identity, through industry-led grouping initiatives, mainly through the promotion at events. Deploying mixed-method data collection and document analysis, I examine the interplay between innovation policy and emerging sectoral structures in the space sector and pose further questions for a more detailed understanding of the “Space Glen” phenomenon – in particular, how is the “Agile Space” branding bringing it all together and what does it mean for innovation practices and organisational behaviour, which is analysed further in Chapter 2.

Chapter 2: Agile Space Living Lab – The Emergence of a New High-Tech Innovation Paradigm

The second chapter delves deeper into the global space industry’s structural transformation through the emergence of “New Space” and the way world-leading cluster of New Space industry has emerged in Scotland. Critically, this development is being pitched by actors in the sector as a new approach to an innovation system, which the players refer to as “Agile Space”, based on a consolidation of cross-sector competencies within a loose value chain integration. However, I propose that the emergence of the Scottish New Space Sector is crucially linked to the Living Laboratory (Living Lab) conceptualisation of the innovation practices and processes within the Agile Space approach. Hence, I map the key features of the emergence and development of the New Space Industry in Scotland and analyse the alignment between Agile Space and Living Lab paradigm, before proposing a critical further research agenda suggesting to focus on interrelated changes to new product development processes and innovation networks (in Chapter 3), as well as examine the critical role of innovation intermediaries (in Chapter 5).

Chapter 3: New Space and Agile Innovation - Understanding Absorptive Capacity Through Examining Innovation Networks and Moments

This (third) chapter is developing a detailed analysis of the organisational structures and practices in SMEs’ knowledge absorption from a network of innovation partners. In particular, it explores the relationship between the openness of the innovation process through innovation networks and changes to new product development practices in firms. It proposes a new conceptual tool of “innovation moments”, to synthesise the key theoretical premises of knowledge management, organisational learning and absorptive capacity literatures. In order to study this vital nexus of phenomena, I deploy a novel mixed-methods approach of combining quantitative ego-centric Social Network Analysis (Ego-SNA) and qualitative derived narratives of product development experiences, to study the emergence and development of the New Space Sector in Scotland. The findings show that the type of the SME – "traditional" versus New Space and upstream versus downstream – is clearly related to the structure of the firms' ego-centric innovation networks and their position in the composite whole network. Furthermore, by using qualitative case study data I show that the firms' typology is also closely related to internal organisational features, in particular flattening hierarchical structures and the formalisation and standardisation within NPD processes. Overall, I argue that the interlinking of these two elements is poised to describe a cultural shift in the approach to innovation networking and new product development (NPD) process management, understanding of which is a critical element of examining Open Innovation in SMEs and depends extensively on innovation intermediaries, which have a central role in the innovation network. (As is explored in the second part of the thesis.)

Part 2 – The Role of Innovation Intermediaries

Chapter 4: Innovation Intermediation - Towards a Functional Classification of Interventions

The fourth chapter brings to light the ever-increasing importance of innovation intermediaries in the analysis of (open) innovation systems. In particular, the current state-of-the-art literature is being challenged by a lack of theoretical and operational clarity, as seen in incomplete, overly complex and dysfunctional classifications. Furthermore, demand is growing for straight answers to practitioners' questions, such as: what type of intermediation is appropriate in a given context? Hence, this chapter puts forward the findings of a systematic review of literature to address these critical conceptual issues, by a) further evolving the definition of innovation intermediaries; b) framing innovation intermediation within geographical and sectoral systems of innovation c) shifting the focus of analysis from intermediaries as organisations towards intermediation as interventions; and d) developing a classification framework for these interventions, based on dividing lines emerging from the review of innovation intermediaries literature. (This new framing is then put to test by empirically applying it to the studied Space Sector in Scotland (in Chapter 5).)

Chapter 5: Enablers, Equippers, Shapers and Movers - A Typology of Innovation Intermediaries Interventions and the Development of an Emergent Innovation System

In the fifth chapter, more detail is developed on the premise that innovation intermediaries are seen as crucial and critical players in the development of emergent high-tech sectors. I empirically deploy the new theoretical framework for analysing innovation intermediaries interventions within a case study of the New Space Sector in Scotland. Based on secondary document analysis and mixed-method empirical research using primary data from surveys, interviews and social network analysis, I examine: a) the make-up of the innovation intermediation organisations in the Scottish Space Sector, b) their sectoral positioning through innovation networks and c) the interventions they deploy and effects they expect to have on the sectoral actors. Based on this analysis, I propose a new typology of innovation intermediaries' interventions, in order to link them with their identified systemic roles of enablers, equippers, shapers and movers, which correspond to varied political and economic mandates these organisations have. I also argue for a more holistic approach in designing new interventions. (Hence, the need for an organisation level-study as developed in the next and last empirical Chapter (6).)

Chapter 6: The Ten Million Euro Question - How Do Innovation Intermediaries Support Smart Specialization?

In the sixth chapter, I focus on a direct application of policy through innovation intermediation, thus, completing the proverbial circle from the start of the thesis (when questions of innovation policy were explored). In particular, I focus on Smart Specialization Strategy (S3) which has become a dominant regional economic development field with significant traction, in particular within the European Union. However, questions are being raised about its operationalization and a gap has been identified with respect to the role of innovation intermediaries' interventions in support of the developing regional-sectoral innovation systems. In particular, reasons for diverging policy approaches of "niche specialization" versus "regional advantage" in comparable situations should be examined to illuminate the contextual factors impacting the interpretation of the intermediaries' mandates. In this chapter, I apply the newly developed innovation intermediaries interventions framework to the cases of two leading investments in innovation intermediation in the emerging New Space sector (Space-SI and Higgs Centre for Innovation) in two EU NUTS level 1 regions (Slovenia and Scotland). In particular, I examine points of difference between research and development (R&D) and business development (BD) support foci in the two locales, noting some of the contextual factors associated with them and arguing for the long-term balancing of the two approaches.

Discussion

Chapter 7: A Multi-level Perspective Geographically-bound Sectoral Systems of Innovation Framework (MLP-GSSI) for Analysing Open Innovation Transition in SMEs

In the first discussion chapter (chapter seven), I outline how research in innovation has suffered from a divergence of approaches, specifically, the split between the macro and micro level of analysis and between the normative positivist and analytical interpretationist studies. However, such divergence is counterproductive in the face of critical challenges to innovation policy and practice, posed by the contemporary global challenges. Noting existent areas of convergence, from past literature and over the work presented in this thesis, I propose to further merge the science and technology studies (STS) insights into the contextual nature of innovation structures and processes, with the innovation studies (IS) systemic perspective(s). This is done by outlining a new integrated multi-level perspective (MLP) understanding of open innovation (OI) transition interrelated with modified (geographically-bound) sectoral systems of innovation (GSSI). To achieve this, I advocate the merged analytical contextual framing of the three (sectoral) systems of innovation elements: institutions/socio-technical regimes, actors/networks and socio-technical systems of knowledge/technologies (STSKT) as a symmetrical nested hierarchy within the joined MLP-GSSI framework. Using the empirical work in chapters one to six as the base, the empirical framings are identified as macro-level geo-sectoral innovation policy, meso-level Living Labs, and micro-level structural absorptive capacity. I also propose linking these framings through understanding the innovation intermediaries' interventions typology and the concept of innovation moments, thus integrating the applied theories into one multi-level framework.

Chapter 8: The PERIpatetic Approach - On Becoming an Uninformed Insider

This final substantive (eight) chapter is outlining a detailed reflection on an emerging shift in research philosophy within social science studies, involving greater proximity to participants through longer-term interaction and embeddedness in various contexts of Participatory Action Research. It builds a practical epistemology for researching innovation, i.e. the PERIpatetic Approach, outlining my experience of multi-level study of innovation processes and practices within the (New) Space Sector in Scotland. Combining the understanding of abductive epistemology, best practice in researching professional elites, and multi-method research design and data collection, I develop the "participatory strategic ethnography of innovation" inspired by the Biographies of Artefacts and Practices and frames the "uninformed insider" positionality as critical advances within innovation research. I believe this is a valuable contribution to both the knowledge of research design and practice, as well as a welcome account of the research experience.

Epilogue

Conclusion

In the concluding chapter, I sum up the thesis and reflect on the conceptual derivation of the main contributions to knowledge, examine research limitations and propose opportunities for further study. I particularly expand on the significance of the cultural shifts in innovation practice, as well as in innovation research, by highlighting some of the more muted and nuanced observations throughout the empirical work and the theoretical development.

PART 1 - THE EMERGENT NEW SPACE SECTOR IN SCOTLAND

Chapter 1: New Space and Innovation Policy - Scotland's Emerging "Space Glen"

Introduction

The Space Sector is currently undergoing a major industry transition, often described by players as the emergence of "New Space" (Adlen, 2011), which is defined on one hand by promises of radical technological innovation, especially through hardware cheapening and miniaturisation (Pallegar, 2018) and on the other hand wider access to open satellite data (Harris and Baumann, 2015). In particular, these developments have expanded towards new user groups (local government, educational sector, SMEs) with the introduction of New Space developers in previously peripheral geographies (Devezas, 2016). One of such key locales is Scotland in the UK, where a dynamic ecosystem of New Space firms, mainly small-to-medium-sized enterprises (SMEs) was established, something referred to as the emergence of the "Space Glen" (*Business Insider*, 2018).

One of the underpinning factors for the transition and expansion of the Space sector is the emergence of new markets based on the commercialisation of space activities away from Space Industry's traditional alliance of government public procurement and multinational corporations (Hazelrigg and Hymowitz, 1985; Cohen and Noll, 1986; Whealan George, 2019). This alliance was linked to the military origin of the majority of governmental space programmes, something referred to in the past as being part of the military-industrial complex (Adams and Adams, 1972). As such, public sector procurement of civil and military space technology has been the pivotal part of space policy since the Space Race (Bille and Lishock, 2004).

However, with the "digital revolution" in the 1990s and 2000s, small (nano-) satellites and data-analytics platforms are now within reach of private customers and the New Space development is, in fact, a feature of more broad innovation policy, rather than a purely space one (Maryniak, 2005; Szajnfarber, 2014; Petroni and Bianchi, 2016; Kishi, 2017). Hence, the focus is moving away from the traditional government role in the sector and from multinational corporations towards SMEs as centres of economic activity. However, government policy and positions of a variety of actors still crucially shape the development of the "New Space" sector through innovation policy and related interventions. This collective "buzz" is particularly felt in geographical contexts where the past involvement with the Space Sector was at best peripheral, such as the space industry in Scotland. Though many such ambitions arose in many locales around the world, in particular how did the now well-known Scottish "Space Glen" develop?

In order to try to answer this question and understand the emerging trends is examines, I carried out a scoping four-stage enquiry in the development of the Space Sector in Scotland presented in this paper. The rest of this paper is structured as follows. In the next two sections, I outline the overall framing of the Space Sector value chain and its transition to New Space, exposing the need for a better understanding of SME innovation dynamics. I then propose a set of four scoping research question and a mixed-method approach to answering them. As a result, in the subsequent four (combined results and discussion) sections, I develop economic, policy, geography and community angles on the sector. Specifically, I first analyse the economical significance and historical context of the policy development of the wider UK Space Industry and its Scottish subset, which is examined through the UK-wide innovation agenda and the Scottish regional economic development one, leading to dispersed investment. Secondly, I survey the clusters that make-up the Scottish New Space Sector. Thirdly, I examine how Scotland's Space Sector has become "unified" and known as one of the growing places for the New Space industry by developing a regional-sectoral identity through a series of shared events. Fourthly, I explore a series of actors views on these political aims and economic configurations of the sector. In conclusion, I discuss some limitations of the current study and propose a further research agenda.

Background Review: The Structure of the Space Sector

Globally, the increasingly varied and interconnected economic activities concerning Outer Space[4] are routinely collectively labelled "The Space Sector", which is defined by the OECD as including:

[4] Outer Space is ordinarily (though not legally) defined as everything above approx. 100-150km from the Earth's surface (Vosburgh, 1970).

> *"[…] all actors involved in the systematic application of engineering and scientific disciplines to the exploration and utilisation of outer space, an area which extends beyond the earth's atmosphere."* (*OECD Handbook on Measuring the Space Economy*, 2012)

Sometimes, this is also referred to as the Space Industry or indeed included in bigger terms such as Aerospace, which incorporates Aviation as well. It is important to note that for the purpose of the analysis presented here, which is mainly based on secondary sources, two areas of the Space Sector activities are excluded. The first of these are Military/Defence Applications, which is by and large classified data, but rumoured to be up to ten times the worth of government's civil space exploration programmes. The second is direct public investment in Space Science and Space Exploration for scientific purposes, which is delivered through research grants and multi-national agencies subscriptions. Though this is often not accounted for directly, its impact on the economy is captured in the overall econometric data.

The different technology-based sub-divisions of the value chain are at different development stages, for historical and commercial reasons (Mishra, 2004; Adlen, 2011; Space IGS, 2011; Willetts, 2013). The Space Sector analysts distinguish between three key types of technology applications and consequently products/services involved: Earth Observation (EO), which is predominantly based on multi-spectral imaging; Geo-Positioning and Navigation, most commonly associated with geo-positioning systems or GPS; and Telecommunications and Broadcasting, with satellite television being the dominant part of this arena (Sullivan, 2009; Space IGS, 2011; Satellite Applications Catapult, 2014). All three of these applications are enabled by the work of many scientific disciplines and crucially by civil, mechanical, electronics and aerospace engineering. The most mature and profitable of these areas is the telecommunications one (OECD, 2007b) since the signal transmission was the first and easiest product/service to develop, requiring only three types of technologies: launch capability, in-orbit power generation and signal reception/transmission. These technologies were developed early in the commercialisation of the space exploration, whereas more complex components, such a digital signal processing (key for Earth Observation) and high precision atomic clocks (key for Satellite Navigation), were slower developed and adopted, and are by and large still too expensive for private commercial deployment, although this is now changing.

Analysts ordinarily split the Space Sector into three main areas according to the overall value chain: upstream - consisting of hardware development and launch infrastructure -, mid-stream - satellite launch/deployment, operation and data downlink -, and downstream – made up of data processing and applications (OECD, 2007b; Adlen, 2011; Satellite Applications Catapult, 2014). In the next three sub-sections, I examine the three main parts of the value chain in greater detail, in particular, exposing the historical make-up of the value chain, before moving on to address its expansion in the New Space Arena in the next section.

Upstream

The high-tech R&D and technology development demands a large-scale engineering-based business-to-business market. Due to the consequent need for significant upfront capital investment and resources, the upstream segment of the global Space Sector value chain is dominated by "big global players", such as multinational corporations Airbus, Boeing, Lockheed Martin and others (OECD, 2007b; Summerer, 2011). Investment in projects delivered by these upstream players are often very expensive and only within reach of governments (in particular, the USA and Russia), international agencies (such as ESA) or a small number of corporations who specifically operate in space-related business (e.g. satellite TV broadcaster BskyB and satellite telecommunication provider SES) (Summerer, 2011). Importantly, due to the complexity of products and the technology-requirements-dominated design, the innovation model in this segment is closed, with a very large amount of IP protection, commercial secrecy and often issues related to national security (Summerer, 2011; Johannsson *et al.*, 2015; van Burg, Giannopapa and Reymen, 2017). As will be discussed in the later section "Policy Angle: Space and Innovation Policy in the UK", this is also one of the reasons that a slower rate of development and growth is predicted in this area in the UK and globally (Space IGS, 2011; Satellite Applications Catapult, 2014; Bryce Space and Technology, 2016).

Traditionally, in the upstream arena the smaller players, SMEs and entrepreneurs, only provided a limited range of specialised (niche) products, however, several smaller companies have managed to scale up, quite often only to be bought up by one of the "big players" (Petroni and Santini, 2012). As a UK example, the large multinationals Finmeccanica (in 2008) and Telespazio (in 2011) acquired systems engineering firm Vega (Telespazio, 2011), and the conglomerate Airbus took over the small satellite manufacturer Surrey Satellite Technologies (SSTL) (Surrey Satellite Technologies, 2019). Across Europe, the four large industrial holdings represent approximately 70% of the Space Sector's workforce and win 70% of the European Space Agency (ESA) contract spending (Summerer, 2011). However, as the satellite technology is becoming smaller, cheaper and more standardised, an opportunity is emerging for entrepreneurs to capture the "New Space" markets through Mini-, Micro-, Nano-, and Pico- Satellites. These roughly correspond to satellite sizes of less than 500kg, 100kg, 10kg and 1kg respectively (Satellite Applications Catapult, 2018).

Midstream

The midstream enterprises in satellite launch, on-board systems management and operations, and data acquisition are often attached to either downstream or upstream segments. However, there is a growing interest in the development of this diverse segment of the value chain, as technological miniaturisation seems to be expanding the demand for its services. In particular, new opportunities are arising in the area of small launch capabilities, in particular expanding the capacity and geographical distribution, as well as the proliferation of technological systems (Lim, 2016; Niederstrasser, 2018). Hence, "spaceports" are being conceptualised as a significant way forward (Frost and Sullivan, 2018), moving towards horizontal capability, i.e. airborne launch, and into new locales (Mccleskey, 1999; Gulliver and Finger, 2010), including Scotland.

In terms of the downlink, as all of the data are transmitted from locations in space, "open access" was initially a default position and there was no specific data downlink element to the value chain. However, with the increased volumes of data traffic, particularly in the most advanced EO activities, the industry moved to "packaged" high-bandwidth downloads between specifically tasked satellites and selected ground stations. This is not only a technical challenge, but it is also limiting data receiving to satellite's "handlers". In many cases, this restrictiveness is counteracted by "open data" policies (Woodcock *et al.*, 2008; Harris and Baumann, 2015), i.e. protocols for "open access" sharing after the high-resolution data download, which is a key component of the ESA mandate and hence incorporated in all ESA EO projects (Aschbacher and Milagro-Pérez, 2012; Moreno *et al.*, 2012; *Open Access at ESA*, 2019), though more concerted effort in archiving and developing data pipelines is being called for (Wulder and Coops, 2014; Turner *et al.*, 2015).

Downstream

In contrast to the upstream segment, in particular, the downstream part of the sector has for a long time been a more open and competitive environment as issues of national security aside, broadcasting and telecommunications - and lately Earth Observation and positioning navigation as well - are built on the principle of a wide access to data and two-way interaction between the data producer or enabler (i.e. the space company) and the user or consumer (Elbert, 2004). A good anecdotal example is Sputnik, the first artificial satellite ever to be launched in 1957. This USSR built device transmitted a series of "beeps" whilst in orbit around the Earth, which every citizen in every country could hear as long as they had a radio receiver (Dickson, 2001). With the advancement of encryption technologies in 1970s-1980s, these data became commercially useful, i.e. satellite TV works only with a decoder (Hanas, Toonder and Pennypacker, 1981), however, the distributed nature of data receiving and low requirements for processing remain dominant in broadcasting/telecommunications and navigation part of the sector, making it the largest and most established part of the downstream space industry - and the most profitable, too.

In addition, even at the height of the Space Race, the science done in space and from space was publicly discussed and many modern research satellites transmit information in such a way that anyone with appropriate receiving technology can collect it (for example Meteosat, SeaStar and the NOAA series) (Taylor, 2019). However, both through the previously mentioned wider availability of high-resolution data as well as increasing access to computing power, the need for (advanced) data processing and analysis gave rise to the new commercial opportunities. These opportunities are further enhanced by significant political commitment and investment into global sustainability and development programs based on space-powered geoscience intelligence (Anderson *et al.*, 2017), which is largely delivered through science-driven spin-off and entrepreneurship.

The entry of these new players in different segments of the value chain (nano-satellites in upstream, small-scale launch providers in midstream and open access data applications in downstream) marks what the industry analysts describe as the transition towards the "New Space" era (Adlen, 2011). In particular, a significant expanse of the space applications arena and refocusing of infrastructure towards larger distributed systems of individually smaller, cheaper and more dynamic units, mark a departure from past innovation practices in the Space Industry, towards a more open, cooperative, systemic configuration of players. In the next section, I analyse the history behind this transition and outline aspects of theories of innovation, which may help to develop a better understanding of the changes it brings to the value chain.

Industry Transition and Emergence of “New Space”

In the past few decades, the global Space Industry Sector’s historic development moved into its third phase. After the initial state monopoly in the 1960s and 1970s (1st phase), the technology was commercialised in 1980s and 1990s by large multinational corporations (2nd phase) and is now (since 2000s) being democratised through innovation and entrepreneurship (3rd phase) (Adlen, 2011; Space IGS, 2011). The latest development trend (from 2nd to 3rd phase), possibly setting the future of the sector, is commonly described within the Space Industry as “New Space”. This term is describing a set of key changes to the make-up of the Space Sector’s products and the introduction of new markets and liberalization of established ones, which used to be dominated by government-backed or large corporate monopolies (Space IGS, 2011). This is particularly visible in three trends: first, an increase in commercial tendering for government programmes, in particular with regards to “services” such as launch capability, operations management, etc. Though the corporate monopolies are still dominant in the “classical market”, disruptive technologies are making this area much more competitive, for instance through entrants such as SpaceX (working on reusable launch rockets), Virgin Galactic (space tourism), etc (Grady, 2017). Second, the Smaller Satellites (<500kg) market has been established, operating outside the traditional paradigms, with relatively cheap, “not-(as)-complex”, mass-produced products. Third, there is a significant expansion of space data market**,** driven by the high-tech tail end of the development of data science and global connectivity creating data storage, analysis and access to information on an unprecedented scale. For instance, there is increasing investment into open-access space data by global players, most notably the European Union (*Space: a new European frontier for an expanding Union - An action plan for implementing the European Space policy*, 2003).

Electronic devices, which are a key component of space technology, were made more versatile, compact and also cheaper with the IT advancement over the past 20 years (Pallegar, 2018). This not only made more complex missions possible, previously burdened by the weight of the equipment since the cost of spaceflight is still measured in the number of kilograms one needs to launch into orbit but are also cheap enough for them to be treated as expendable (Swartwout, 2004). For instance, CubeSats, the most popular form of Nano-sats, are of a size of 10x10x10cm (>10kg) and can be built for as little as £30,000-50,000 (Esionwu, 2014). However, due to the (small) size of these devices, the power generated by the solar panels mounted on them is insufficient for some applications, though solutions such as launching a constellation or network of several smaller satellites are being explored.

However, an additional driver for this development was the re-definition of the Space Sector actors, with both new countries (Devezas, 2016) as well as new communities emerging (Adlen, 2011; Pomeroy, Calzada-Diaz and Bielicki, 2019). Though the latter will not be examined in too much detail in this paper, it is particularly interesting that these new communities are being actively developed. On one hand, (super-) angel investors with interest in space, for instance, Elon Musk (SpaceX), Richard Branson (Virgin) and Jeff Bezos (Blue Origin) (Adlen, 2011), are attracting significant international expertise into their (new) entrant firms' R&D processes. On the other hand, through the establishment of a "Global Space Community", composed of space enthusiasts now globally connected via the internet, actual public/citizen science and crowdfunding operations (e.g. Mars One, Lunar Mission One, Planetary Society) are being enabled (Pomeroy, Calzada-Diaz and Bielicki, 2019). Whilst there always was a large community of space enthusiasts, they were previously unable to participate in most of the actual developments due to key barriers to entry, such as the need for amassed expertise and significant capital investment.

However, New Space-related changes are taking hold in all aspects of the Space Sector (Adlen, 2011). Particularly noted in the (popular) media is the commercial launch capability in the upstream segment of the industry, which is delivered by emergent large corporations bankrolled by the previously mentioned angel investors (Kyle, 2016; Grady, 2017; Howell, 2018). However, due to the persistently high development costs and reliance on public procurement contracts (Hirsch, 2015; Semangdal, 2017), the more economically and societally interesting New Space development is in satellite miniaturisation and proliferation of space data application solutions (Culver *et al.*, 2007). In particular, SMEs are key for the (smaller end) of the Small Satellites market and emerging data applications, where the transition to New Space is being most clearly demonstrated. With the cheaper core technologies and easier access to space data, companies are being set up on the basis of a new generation of products and services (e.g. nano-satellites, data analytics platforms, etc.), which are being developed more closely with the end-users (Vidmar, 2019b) (e.g. local government, multi-national corporation, community groups, etc.) and are based on "productisation" of R&D solutions into mass-production (Vidmar *et al.*, 2020). In essence, this approach, new to the Space Industry, is transforming the SMEs involved into end-product manufacturers, rather than business-to-business subcontractors and suppliers (Vidmar, 2015).

With these changes in market access strategy and investor profiles, the innovation dynamics are also changing. In particular, the new product development is moving away from focusing on single-mission complex products and services (CoPS) and towards mass manufacturing. Hence, if innovation is split along what core management literature describes as four categories (or "4Ps") of innovation: "product", "process", "position" and "paradigm" (Tidd, Bessant and Pavitt, 2005), my summative analysis of the trends outlined above shows that all four of the "4P" innovation categories in the New Space Sector are changing substantially, as outlined in Table 1, below. Such significant changes also align well with the famous Schumpeterian definitions for radical innovation (Freeman, 2003), modified to take note of the specific technological/sectoral focus (Malerba and Orsenigo, 1995), as new products, processes, value chains, markets and business models are all emerging within the sector.

Type of Innovation	**Typological Description** (from Tidd et al., 2005, p. 10)	**Changes observed in the New Space Industry**
Product Innovation	*change in products or services an organisation offers*	A move to a **new generation of products and services**, in particular, cheaper and (more) standardised upstream components; and increased exploitation of space data for non-space downstream products and services.
Process Innovation	*changes in the ways in which they are created and delivered*	**The transition from technology-driven R&D to co-development with user**s. The key link between the two is "productising" – making specific products modular or easily configurable for the end-user.
Position Innovation	*changes in the context in which the products/services are introduced*	The move from **single mission development to mass manufacturing in terms of market positioning**, SMEs to sell directly to end-users, needing a wider network and a vertically-joined-up value chain.
Paradigm Innovation	*changes the underlying mental models which frame what the organisation does*	Paradigm innovation, a **shift from SMEs considering themselves suppliers**, they are now more interested in engaging end-users and want to build large

		platforms to tap into large(r) markets and grow their business.

Table 1 - 4Ps of innovation analysis of the transitions observed in the New Space Industry.

Though some analysts challenge the notion of a natural state monopoly over the Space Sector as relics of historical involvement (Maryniak, 2005), that perception is prevalent in particular in the context of the main space powers such as USA (Launius, 2003; Grimard, 2012). Furthermore, space policy has always been seen as a critical domain for states and individuals attempting to project political leadership (Holland and Burns, 2018), which was also recently evidenced in the UK parliamentary context, with MPs attempting to frame their role in championing their constituencies, whilst referencing "national aspirations" (Kelso, 2016). However, in the post-Cold-War era, these policies predominantly revolve around the power of innovation (Szajnfarber, 2014; Petroni and Bianchi, 2016). In particular, on one hand, the discourse is built on the expectations of technology transfer from publicly funded basic and applied science (Petroni and Verbano, 2000; Petroni *et al.*, 2013; Venturini and Verbano, 2014), and on the other hand, the creation of new markets for the Space Sector applications (Webber, 2013; Genta, 2014; Denis *et al.*, 2017; Vasko *et al.*, 2017) as part of economic (development) policy. Hence, the Space Sector's growth is being supported by deliberate top-down policy interventions, often delivered dispersedly by publicly-backed innovation intermediaries, whilst it also relies upon a pre-existing environment and bottom-up entrepreneurial action, i.e. the Open Innovation approach (Chesbrough, 2003, 2006; Chesbrough and Vanhaverbeke, 2011). The latter has been extensively studied in particular in Europe (Johannsson *et al.*, 2015; van Burg, Giannopapa and Reymen, 2017), however, there is a gap in in-depth studies of links between the policy frameworks and emerging specific innovation ecosystems (Kishi, 2017).

Developing critical understanding how SMEs interact with each other to frame an emergent New Space cluster is of particular interest, as it underpins the belief that technology transfer and bottom-up industrial entrepreneurship are sufficient conditions for the success of current space innovation policies. One of the most significant examples is the emergent Space industry in Scotland, UK (Scottish Enterprise, 2016b, 2016a; Macdonald, 2017; *Business Insider*, 2018; Harris, 2018). Hence, in order to fill this gap and understand the interplay of the innovation policy and New Space entrepreneurship better, in particular in the context of a smaller regional unit, I propose a further analysis of the historic and contemporary development of the Space Sector within Scotland – the "Space Glen" – with particular reference to innovation policy and industry perspectives, collective and individual.

Methodology: Unpacking the "Space Glen"

Investigating the interaction between space/innovation policy and industrial/entrepreneurial activity requires a multi-layered approach, to unpick each element separately and then contextualise them with each-other. The scoping study presented here is based on both comparative analysis of secondary sources (major policy and econometric trends) (Bowen, 2009) and primary data collection by mapping out the emergence of the specific interplay between policy and industrial/entrepreneurial activity. It is structured around four-partite enquiry of the framing of overall economic and policy development (from document analysis), the geographical configuration of industrial/entrepreneurial activities (participation in over 45 industry event and site visits) and the practitioners' views of all of these (with five scoping interviews).

In the following sections, I begin with an analysis of the UK and Scottish Space Sector and the plans for its expansion, which represent a distinctly institutionalised view of this dynamic and challenging economic area. In doing so, I have formed questions about the experience of actors as my research philosophy being build on abductivist critical realism (Blaikie, 2004; Shank, 2008; Ong, 2012) – i.e. following the questions emerging from analysis and interaction with the field of study. In particular, having examined the historical and political context, as well as informally engaging with key stakeholders, I distilled four interrelated strands of enquiry:

- What is the economic significance and policy landscape of the UK and more specifically Scottish Space Sector?
- How is the Scottish Space Sector configured/structured?
- How and where has the "Space Glen" framing come about?
- What is the actor's view on these developments?

To answer these questions, I have firstly conducted a detailed survey and analysis of secondary sources (Bowen, 2009)[5], cross-referenced with informal discussions with the

[5] Secondary data sources (documents) were mainly sourced by surveying three collections: the UK Space document repository (https://www.ukspace.org/publications/), government sources, in

gatekeeper organisation and the Scottish Space Sector players[6], to map out the economic profile, trends in policy agenda and sector's geographical structure. This was summarised and structured using thematic narrative analysis to address the main questions relating to formal economics (in particular turnover and its segmentation, employment statistics and companies' structure), policy (history of space policy, formation of innovation policy and Space Sector targets) and geographical positioning (the number and location of firms and their clustering).

Secondly, I have addressed the conceptualisation of a joined-up vision of the "Scottish Space Sector", i.e. the "Space Glen" as it emerged through a variety of institutional players and in particular through conferences and events (Nyqvist, Høyer Leivestad and Tunestad, 2017), which I examined ethnographically through participatory observation (Tedlock, 1991; Atkinson and Hammersley, 1998; Musante and DeWalt, 2010; Jorgensen, 2015; Spradley, 2016) (please, see a list of sites in Annex 1). This was based on unstructured information gathering through taking part in activities within the sector through one central gatekeeper, a team delivering one of the flagship business development projects in the sector.

Finally, in order to have a more complete understanding of how the economic, policy and geographical contexts are perceived by the actors in the sector and hence provide a descriptive critique of the "Space Glen" conceptualisation, I have carried out a set of five scoping semi-structured interviews (Ostrander, 1993; Welch *et al.*, 2002; Harvey, 2014; Liu, 2018) with carefully selected key stakeholders[7]. As noted by several economics and social science scholars, investigations of professionals' views on a set of topics are best carried out through a technique based on a clear framework of themes, but allowing for enough

---

particular UK Space Agency (https://www.gov.uk/search/transparency-and-freedom-of-information-releases?content_store_document_type=corporate_report&organisations%5B%5D=uk-space-agency) and Satellite Applications Catapult (https://sa.catapult.org.uk/news-comment/), and Scottish Enterprise (https://www.scottish-enterprise.com/learning-zone/research-and-publications).

[6] A list of all Scottish SMEs was produced by cross-referencing data from three main sources – Science and Technology Facilities Council, Scottish Enterprise and Innovate UK.

[7] These scoping interviews are labelled in the results section with letters from A to E. All interviewees were business development executives at various organisations working to develop UK and Scottish Space Sector, from universities, national laboratories and government-backed agencies. The interviews took place at various stages of the sectoral development, interviews A and B at the beginning of this research (Winter 2015), interviews C and D in the middle of it (Summer/Autumn 2017) and Interview E at the end of it (Spring 2019). They lasted 42 min, 43 min, 29 min, 50 min and 37 min respectively and were conducted either via the phone or in person at my office. Interview questionnaire can be made available upon request.

flexibility to digress if addressing important points, i.e. the "semi-structured" approach (Richards, 1996; Odendahl and Shaw, 2002; Stephens, 2007; Bryman, 2016). The questions in the Interview Guide ware deliberately broad and open-ended, to encourage interviewees to address issues without too much influence of the interviewer (Harvey, 2014). In addition to answering any single specific question, my participatory observation of, and interaction with, these different groups of practitioners over several years of my research provided me with a comprehensive overview of how representative the conclusions reached through document analysis and interviews are, as well as framed the identification of the lead themes presented in the next four empirical sections.

Economics Angle: Space as an Emerging High-tech Powerhouse

The economic performance of the overall UK Space Sector is measured with the bi-annual *The Size and Health of UK Space Industry* survey (Oxford Economics, 2010, 2012; London Economics, 2014, 2016, 2019) and by the evolving impact assessment of the Space Sector contribution to the UK economy, put forward in the regularly updated *Case for Space* reports (London Economics, 2009, 2015b). In particular, as presented below, the analyses explore turnover, employment and market/firm structures. Some of the elements of these analyses contain regional breakdown, so can be further examined in terms of the Scottish Space Sector.

The latest results in the 2018 survey (London Economics, 2019), which contain the figures for up to 2016/2017 financial year, show that the long-term growth trends are slowing down overall, though picking up from a slump in 2014/2015. For instance, the average growth rates for 2016/2017 stand at 3.3%, up from the 1.7% low-point in 2014/2015, but still well behind the earlier highs of 7.3% in 2012/2013 and 7.5% in 2008/2009 (Oxford Economics, 2010, 2012; London Economics, 2014, 2016, 2019). This is also in contrast to previous long-term trends, for instance, the 2014 report estimates the average year on year growth in turnover since 2008/2009 at 8.6%, in comparison to 8.8% for the period since 1999/2000 (London Economics, 2014). However, this is perhaps not inconsistent with the overall upwards trends, due to the change in the economic climate in recent times; also, the Space Sector growth was at this point still well ahead of UK GDP (1.5% average since 2008/2009, 1.6% since 1990/2000).

Perhaps unsurprisingly, the key reason given for the overall stagnating growth emerging from the econometric data presented above is "economic uncertainty", initially in the aftermath of the financial crisis (pre-2016) and uncertainty surrounding the UK exiting from the European Union (post-2016) (London Economics, 2016, 2019). This is clearly related to the importance of trade with European partners, as Europe is the destination for 54% of exports (49% in 2014/15) and the source of 69% of imports (inputs) (London Economics, 2019). In addition, EU-funded programmes, such as the global navigation system Galileo, account for 4.8% of total non-direct-to-home-television industry income (London Economics, 2019). Hence, the UK Space Sectors' trade association, which is behind the Space IGS group, has released a leaflet outlining the critical need for continued close cooperation with EU (UK Space: The Space Trade Association, 2017). Though access to EU and overseas markets might continue after implementation of new (free) trade deals[8], the disruption to R&D investment could be a significant setback, as well emerging geo-strategic challenges (Bowen, 2018).

The UK Space Sector turnover in 2016/17 was estimated at £14.8bn, of which less than 1% (£140m) is was generated in Scotland (London Economics, 2019). There was also only very modest growth in this period, only £6m increase from 2012/2013 (which was in line with overall UK trend) (London Economics, 2014, 2019). However, the UK Space Sector was estimated to include 41,929 jobs directly in 2016/2017, of which 7,555 (18%) are based in Scotland, within only 132 firms (9% of total 948) (London Economics, 2019). This is a significant increase in employment since 2012/2013 (by 32% indirect terms and 2.5% over national growth) when Scottish companies accounted for only 5,709 jobs out of 36,696 total (i.e. 15.5%) (London Economics, 2015b). There is also a significant increase in company formation, as it grew from 67 in 2012/2013 to 104 in 2014/2015 to 132 in 2016/2017 (or 35% and 22% increase respectively) (London Economics, 2014, 2016, 2019). The combined figures of relatively low turnover but high employment and firm number growth, shows the significance of (New Space) start-up firms in the Scottish Space Sector, with capital investment (still) being the predominant factor in its current growth; in line with the overarching R&D intensity of the whole sector (London Economics, 2015b).

---

[8] Extended access to USA market is particularly referenced as a potential outcome of Brexit, though the USA's International Traffic in Arms Regulations provides a restrictive trading environment (Kasku Jackson and Waldorp, 2009), even with the US–UK Defence Trade Cooperation Treaty (Bowen, 2018).

Overall, 70% of all the analysed companies in the UK were found to be SMEs, with a highly skilled workforce (75% have higher education qualification) (London Economics, 2016). The Space Sector is found to be very export-oriented with 37.4% of turnover is from exports (growing from 36.4% in 2014/2015 and 31% in 2012/13) or even 65.4% if discounting the effect of the predominantly domestic broadcasters, which make up a significant part of the sector (London Economics, 2016, 2019). Foreign investment in the UK Space Sector was also on the rise, with a 40% increase in 2006-2015 in comparison to the previous decade (London Economics, 2015b). However, the industry is very concentrated with 4 organisations accounting for 67% of total income, and 7 for 76% (London Economics, 2019). This shows in terms of growth rates as well, since very large enterprises account for 56% of overall growth, though the larger SMEs (28% of total growth) are growing particularly fast (31% per annum, compared to very large enterprises at 2%) (London Economics, 2019).

The key industry dominating the sector is Satellite Broadcasting, most of it concentrated in one company, BSkyB. This segment of the sector accounts for 51% of the total turnover(London Economics, 2019). Due to the dominance of space applications (including broadcasting), with a 71% turnover share of the entire sector, it is not surprising that 51% of the Space Sector customers are private individuals (though that is dropping, as it was 78% and 65% respectively in the 2012/2013) (London Economics, 2016, 2019). However, as seen in Figure 3, Scottish firms are much more equally distributed along the value-chain, with 2012/2013 turnover split on 23% in upstream (manufacturing), 33% in midstream (operations) and 44% in downstream (applications) (London Economics, 2015a). This is in contrast with the UK as a whole, where the same split is much more downstream dominated (8%, 12% and 78% respectively), even if the dominating Satellite Broadcasting is excluded (which brings it to 17%, 27% and 52% respectively)[9] (London Economics, 2015a).

[9] This is in stark contrast with employment levels, as in Scotland 93% of Space Sector jobs are in Space Applications segment. This is likely due to accounting practices of the large corporations (in particular BskyB), who break down employment by region, but report turnover at HQ (outside Scotland). Hence, the figures quoted for Scottish Space Sector turnover breakdown effectively include primarily SMEs.

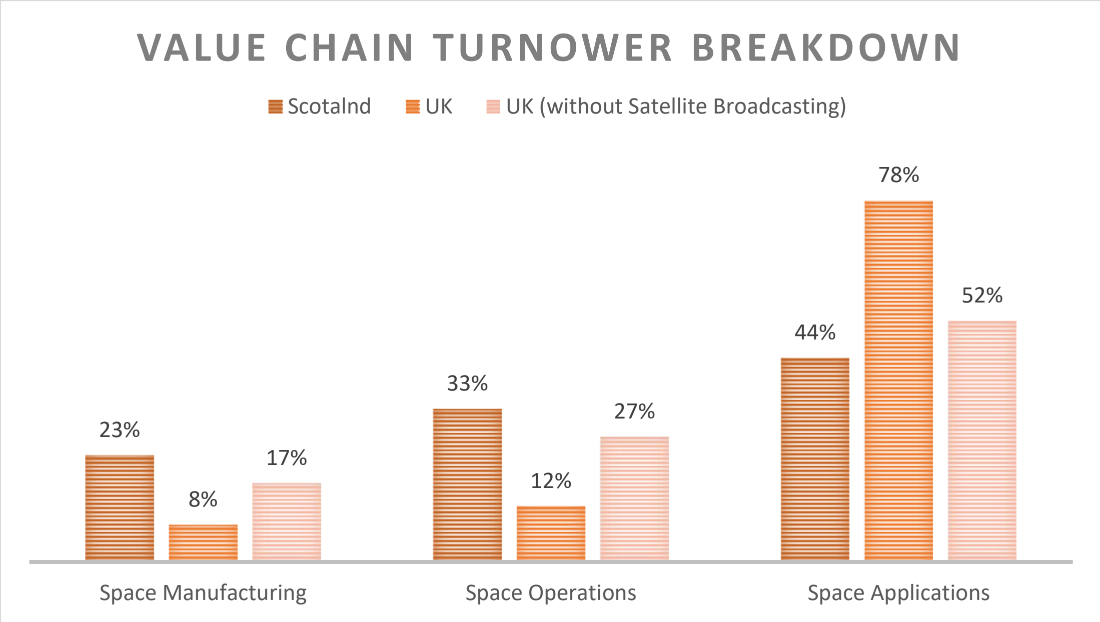


Figure 3 - Breakdown of the Space Sector's turnover by value chain segments for Scotland and the UK as a whole. Data from 2012/2013, as reported in The Case For Space 2015 (London Economics, 2015b) *and Development of the Scottish Space Industry* (London Economics, 2015a).

In summary, the analysis of the UK and Scottish Space Sector economic position points to a specifically fertile ground for Government-backed bottom-up expansion. In the next three sections, I will unwrap the origins of the translation of economic activity into innovation policy and then into practical interventions, then proceed to try to map how the Scottish New Space industry is structured and what are the views of the practitioners involved in it on space innovation policy, which supposedly got them there.

Policy Angle: Space and Innovation Policy in the UK

The UK was one of the first countries to invest in space exploration programme, having space presence in 1962. Crucially for the development of commercial Space Sector, it was the only one to fully commercialise its launch capabilities (Willetts, 2013) – now part of a European concern Ariane – putting the development of (upstream) space technology out of government's reach. Moreover, UK investment mechanisms in this area are peculiar as they joined several (European or American) space-related projects, which were evaluated separately on "value for money" basis (Harvey, 2003, p. 95), without reference to any national framework or programme. In fact, setting up the UK Space Agency, an independent coordination body with its own funding portfolio and a comprehensive development strategy, was completed only in 2010 (UK Space Agency, 2012). Moreover, many other funding agencies are involved in space-related research programmes, with STFC, EPSRC and

NERC being the prime examples, which make the funding landscape complex and somewhat uncoordinated. Consequently, I argue that the overarching policy direction is one of a "free-market-led" development, working to support science and industry, rather than actively steering it through large investment and specific industrial procurement programmes, which is seen by many analysist as a UK specific success (Elefteriu, 2018).

The commercial UK Space Sector has shown exponential expansion in 1980-90s, though this was predominantly on the back of one area – satellite broadcasting – which has limited potential for further growth due to established dominance and market saturation. Since the early 2000s, the sector's growth slowed in terms of turnover, but growth in the number of companies and the variety of products on offer continued. A particular trend was a significant increase in spin-out from UK universities as well as new opportunities within the European Space Agency (ESA). The latter grew significantly over this period (2000-2015) with the backing of the European Union, currently providing 25% of ESA budget through a direct contribution on top of that of the member states (ESA, 2015).

To make further significant gains in terms of growth of the UK Space Sector, a new industry-developed and government-backed strategy was formed in 2010 in the move to "New Space" (Space IGS, 2011). Central to this policy is a government-backed target of increasing the UK share of the global space market from 7% to 10% by 2030 (Space IGS, 2011, 2014; Willetts, 2013), estimated to be worth £40bn out of the £400bn total. Similarly, Scottish Enterprise acting on behalf of the Scottish Government (under UK devolution) has the ambition to see 10% of that economic activity based in Scotland (London Economics, 2015a). These targets are seen as somewhat unreliable today, as they are prone to severe impact from currency exchange rates fluctuations, though current analysis shows that starting from the original base point, the ambitions are being met so far (London Economics, 2016). It is important to note, that as seen in Figure 4 below, most of this growth is expected in the downstream part of the sector (with £37bn out of the £40bn total), which is based on products and services in applications of space technology, rather than the more investment intensive upstream developments.

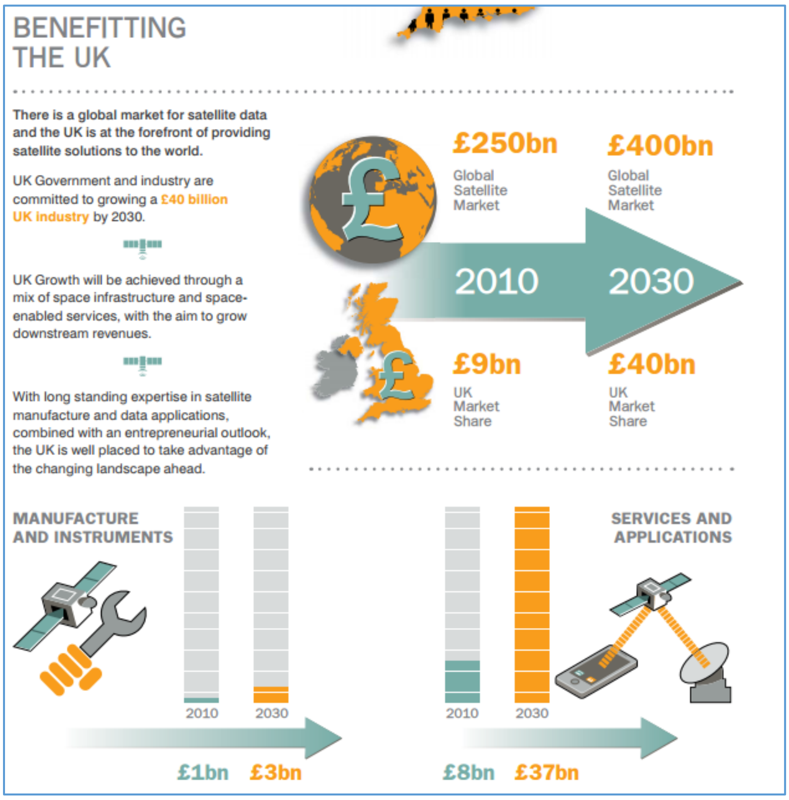


Figure 4 - Projected growth infographic from "Satellites: The Big Picture" (2014)

Critically, these targets are to be achieved mainly through a set of flagship interventions to shape the overall sector, in particular through R&D grants and investment in commercial space activities (UK Space Agency, 2012), but not through a full-scale government-led programme (Elefteriu, 2018). As proposed at the time of its establishment, the UK Space Agency here assumed the role of a funder and regulator, but not actual developer, leaving the R&D to the industry-science collaborations (Space IGS, 2011). This is in line with general UK innovation policy since 2010(Flanagan, Uyarra and Laranja, 2011; Hargreaves *et al.*, 2012; Barker, Sveinsdottir and Cox, 2013; Wright *et al.*, 2015), in part built on a pivotal "8 Great Technologies" policy white paper (Willetts, 2013), which proposed a mix of governmental steer in supporting the existing industries through new opportunity areas. Satellite applications were included, and this framing which also supported the Space Sector has extended into the current UK Industrial Strategy's attention for space(HM Government, 2017). These complementary, yet also diverging approaches are pointing to different perceived niche opportunities in the sector, as well as the complex and dispersed nature of the sector.

For instance, the UK Space Sector's development since 2010 is framed by the *Civil Space Strategy 2012-2016* (UK Space Agency, 2012), which is built upon the UK Government / UK Space Agency backed, but industry-designed *Space Innovation Growth Strategy* (Space IGS, 2011, 2015). On the basis of this strategy Space IGS produced *Space Growth Action Plan* (Space IGS, 2014), which highlights five areas of required actions:

1. *Develop the high-value priority markets identified to deliver £30 billion per annum of new space applications by promoting the benefits of Space to business and Government and engaging service providers.*

2. *Make the UK the best place to grow existing and new space businesses and attract inward investment by providing a regulatory environment that promotes enterprise and investment in the UK.*

3. *Increase the UK's returns from Europe by continuing to grow the UK's contributions to European Space Agency (ESA) programmes and securing greater influence in large European-funded programmes.*

4. *Support the growth of UK Space exports from £2 billion to £25 billion per annum by 2030 by launching a National Space Growth Programme and defining an international policy that will improve collaboration with nations across the world, enhance the UK's competitive edge in export markets and enable targeted and market-led investments in leading edge technology.*

5. *Stimulate a vibrant regional space SME sector by improving the supply of finance, business support, information, skills and industry support.*

However, though these objectives are concise and clear, their implementation is more patchy. The main recommendations and the associated action points were adopted by the UK Government / UK Space Agency through its *Government Response to the UK Space Innovation and Growth Strategy 2014 – 2030* (UK Space Agency, 2014a) and *National Space*

Policy (HM Government, 2015). In particular, the implementation is by and large delivered "through coordination across departments and in partnership with the wider UK Space Sector" (HM Government, 2015) and particularly focus on regulation (UK Space Agency, 2018b) and wider economic development (UK Space Agency, 2019). Though there have been some investments in specific "nation-wide" projects, such as the establishment of spaceport capability (Frost and Sullivan, 2018), the vast majority of the funding available is distributed through R&D grants and business development support (UK Space Agency, 2017, 2019; *UK Space Agency provides funding for three new experiments*, 2018). Though the Space IGS strategy has recently been superseded by the new *Prosperity from Space Partnership* (Space Growth Partnership, 2018) and the UK Government's *Industrial Strategy: Aerospace Sector Deal* (HM Government, 2018), I argue that the main drivers going forward remain. Firstly, these "space innovation policies" are driven by the industry, and secondly, they are born out from the evidenced and projected significant economic impact for the sector and wider UK economy – which leads to a dispersed investment being implemented.

From Policy to Action: The Scottish Dimension

Given the very high ambitions for capitalising on this growth in an economic sector that is primarily outside institutional control, and which has experienced exponential growth mainly on the back of one key sub-area (satellite TV), policymakers and sector leaders are focusing their attention mostly into finding new niche opportunities and consequently to the early stages of business development (UK Space Agency, 2014). These are mainly either specialised hardware products (upstream) or integrated applications based on space data (downstream). Primarily, public agencies are investing in a series of initiatives to ensure that such knowledge "spill-overs" from (academic) research (Salter and Martin, 2001; Autio, Hameri and Vuola, 2004) reach the market via "knowledge intermediaries", which is currently the subject of a broad consensus in the field of science and innovation policy internationally (Howells, 2006; Dalziel, 2010) and in the Space Sector in particular (Comstock and Lockney, 2007; Petroni *et al.*, 2013; Venturini and Verbano, 2014). These ideas have been adopted at both the UK-wide level as well as within the specific regional (Scottish) context, with divergent implementation.

The two main UK-wide flagship programmes linking the innovation policy and the Space Sector growth agenda are the Satellite Applications Catapult and the UK Space Agency, both working in tandem with national R&D and innovation agency, Innovate UK. Through a combination of these organisations, several projects were funded in Scotland, in particular, the first UK built cube sat, UKube-1 (Macdonald and Lowe, 2014), and the investment in developing Spaceport capabilities (Knapp, 2018). In addition, the UK Space Agency, as well as the Satellite Applications Catapult, are investing in business incubation facilities (UK Space Agency, 2017; Satellite Applications Catapult, 2019) and R&D / technology transfer support (UK Space Agency, 2019). Additionally, UK research councils are expanding their space-related technology transfer programmes in this arena, too. Hence, in 2011 the STFC have opened a European Space Agency (ESA) backed Business Incubation Centre (BIC) at their Harwell (Oxfordshire) site, which is now part of the flagship UK Space Gateway, a cluster of space-related R&D based in Harwell (Banks, 2018). More recently ESA BIC in the UK took on the structure of a national programme with several centres (*An Interview with the European Space Agency (ESA's) Business Incubation Centre (BIC) UK*, 2018). As such, this programme is now extending to Royal Observatory Edinburgh (ROE) in Scotland, with the establishment of the Higgs Centre for Innovation (STFC, 2013) and its combined ESA, UK Space Agency and STFC incubation programmes.

These UK-wide initiatives are supplemented with regional programmes, in particular, work coordinated by the two largest Scottish Government's devolved economic development agencies, the Scottish Enterprise (SE) and the Highlands and Islands Enterprise (HIE). The flagship programmes here include high-tech R&D grants and commercialisation support through the SMART Awards programme (Scottish Enterprise, 2018), and wider coordination of sectoral development, in particular through past investment into innovation network integration through Scottish Space Network initiative (Vass, 2013) and by currently convening Aerospace, Defence, Marine and Security Industry Leadership Group (ADMS-ILG). This work is largely underpinned by three main policy documents, *Scotland Can Do* economic development manifesto (The Scottish Government, 2013), which is effectively Scottish Government's industrial strategy, the SE-commissioned *Development of the Scottish Space Industry* report (Scottish Enterprise, 2016b) and the industry-driven *Aerospace, Defence, Marine and Security Industrial Strategy for Scotland* (Scottish Enterprise, 2016a). The ADMS-ILG's Space sub-group has also very recently evolved into a standalone Scottish Space Leadership Council(Callum Norrie, 2018). Overall, I argue that these documents spell a similar mix of coordination and small-scale direct investment as the UK Government's ones, though with a specific focus on making Scotland distinctly advantageous for businesses working in the sector. This chimes with both the regionalisation of innovation and economic policy in Europe / EU through "smart specialisation" (McCann and Ortega-Argilés, 2015; Reid and

Maroulis, 2017) as well as Scotland's leading political party's ambition for Scottish independence (Agnew, 2018).

Overall, I have shown how the space innovation policy interventions on one hand benefit from the UK-wide interest in high-tech innovation for economic growth, as well as on the other hand play out well with the devolved Scottish government agenda of promoting a stronger sense of regional identity. However, the question is emerging as to how has this overall development translated into the emergence of a distinct ecosystem in a traditionally peripheral UK region with respect to the Space Sector? In particular, how did this group constitute its distinct identity and what are its features? Hence, the analytical amalgamation of the actual on the ground development is required, analysing not only the projected visions but the constitution of this ecosystem across firms and other organisations operating in the Scottish New Space Sector. The next section analyses the sectoral configuration and exposes some of the trends emerging from its structural features.

Geographic Angle: SMEs' Clustering and the Present Make-up of the "Space Glen"

The empirical data collected with the extended participatory ethnography and document (news) analysis shows that Scotland is indeed building up an active ecosystem of SMEs and partner organisations, which developed from about 2005. This ecosystem seems well placed to exploit the opportunities of the emergence of the New Space opportunities due to UK's track record in commercialising space technology combined with a strong inter-disciplinary tradition embodied by "city campuses" of Scottish Universities. However, the dispersed investment outlined above has led to niche specialisation and fragmentation. This resulted in three somewhat distinct emerging clusters of activity in Scotland: the Communication Electronics cluster in Dundee, (nano-satellite) hardware engineering and manufacturing in Glasgow and Earth Observation/Geoscience data analytics applications in Edinburgh, creating a "Space Glen" triangle as seen in Figure 5. (Additional significant geographic locations are the proposed sites of Scottish spaceports and the space-based marine services supporting off-shore industries in Aberdeen.)

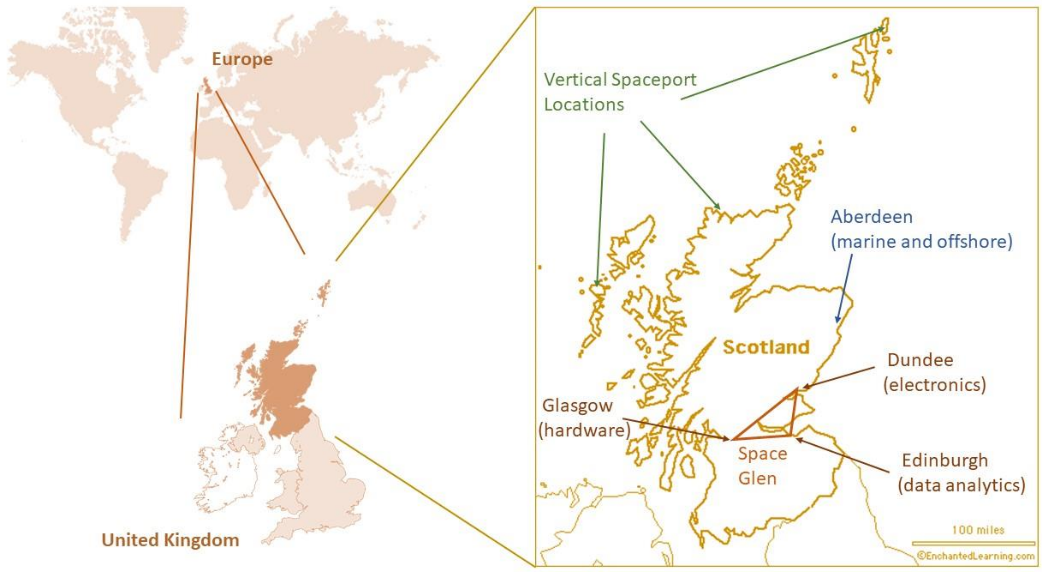


Figure 5 - The geographical location of Scotland's Space Glen and the distribution of its clusters in the corners of the "Space Glen" triangle.

The cluster in Edinburgh, based on software data analytics technologies, is certainly the most economically active, and has the largest number of companies (approx. 10)[10], though not the largest number of employees. The Edinburgh location is not coincidental, as it relies heavily on academic research in geoscience and informatics, both very strong areas of research at the University of Edinburgh. There is also extensive business support provision for the digital economy, with the added appeal of the availability of finance (Harrison *et al.*, 2010). Though pan-Scottish and UK-wide general financial support are available regardless of the business location (Mason and Harrison, 2015), more risky start-up investments are often tied to tried and tested ecosystems (Gregson, Mann and Harrison, 2013). With data unicorns such as Fanduel and Skyscanner, Edinburgh data start-up scene is far more encouraging than most other locations in the UK (Newlands, 2018; *Why Scotland's tech scene is leading the way*, 2019), with extensive ecosystem support (Spigel, 2016).

Similar to the Edinburgh trying to lead globally on downstream space data applications, the Glasgow nano-satellites manufacturing cluster is looking to take on the global space industry by becoming one of a handful and of world-leading centres in small space hardware. Due to the nature of manufacturing R&D as well as production, these are the largest firms with most

[10] Most prominent Edinburgh-based companies at the time of research (2015-2017) were Astrosat, Ecomentrica, Carbomap, GSi Carbon, LTS International, ThinkTank Maths and Topolytics.

employees. In particular, Glasgow is home to a small group of companies (approx. 5)[11], most of who produce cube-sats and pocket-cubes and as they are highly modular and smaller in size, they can be produced more rapidly. In fact, in 2016, 60 nano-satellites were produced in Glasgow, making the city the largest satellite producer outside Silicon Valley (Clyde Space, 2017; Macdonald, 2017). Interestingly, due to Glasgow's investment in support for developing digital companies and the lower cost of infrastructure (and living) in comparison to Edinburgh, some of the data firms previously associated with Edinburgh are now also being either set-up or relocated to Glasgow. Closely related to the hardware manufacturing segment of the sector is also the Dundee cluster, specialising in space electronics (sub-)systems. Though this is the smallest of the three clusters (fewer than 5 firms)[12], it is also the oldest, as space data acquisition was part of the research and service provision here for over 30 years. This is also the most research-driven of the groupings, with a particular unit of Dundee University and its spin-outs being responsible for most of the development.

In addition to these clusters, there are a few SME-size consultancies in and around Aberdeen, which are not really integrated into a wider ecosystem and not very visible to the rest of the sector in Scotland. They are primarily part of a subcontracting service industry, supporting shipping and oil extraction in the North Sea. As such, their primary concern and motivation is user-driven demand for technology capabilities, many of which are developed internationally and imported to UK/Scotland as end products. A notable exception to this modus operandi is a company called Veripos, providing high-precision GPS positioning equipment for the oil and gas industry. Though they do feature in-house R&D activities, they focus almost exclusively on providing products and services to energy and maritime industries and are far more integrated into those sectors than in the Space Sector. Furthermore, their acquisition in 2014 by a global multinational group Hexagon (Murfin, 2014), led to a different innovation model within the company, collaborating more with international units of the corporation than external partners in Scotland. A similar acquisition of an emerging space tech company also happened in the case of 2016 takeover of Optocap, a Livingston-based company, by Alter Technology, a division of TUV Nord (McCulloch Scott, 2016) and they, too, are not very visible within the Scottish Space community.

[11] Main firms in the time period were Alba Orbital, Clyde Space (AAC-Clyde Space) and Spire.
[12] Key SMEs here were Bright Ascension and STAR-Dundee.

The low level of interaction with the local innovation ecosystem can also be observed in the case of bigger multinational corporations, though they engage with aspects of policy development. Of particular note here are Leonardo (Edinburgh), BAE Systems and Lockheed Martin (West Coast), BskyB (Central Belt), and Axon Cables (Fife). Like with Veripos and Optocap, most of these operations are "branches" of very large enterprises, with dispersed innovation and business development processes. Furthermore, as some of these firms are intensely defence oriented in their operations, their innovation processes are very closed and restrictive. As such, they are less rooted in the regional ecosystem and have a less intense interest in the emergence of the "New Space" part of the sector, as well as a more cautious approach to the global sectoral transformation, described earlier.

There are a few more companies scattered across Scotland (about 5), who do not clearly belong to any of these clusters. There are several data transition developers and re-sellers in Ayrshire (SW Scotland) and Moray (NE Scotland), though little of that development is carried out in Scotland. There are also emerging interests in linking geospatial and earth observation information with agriculture, with several developers and retailers of such products emerging, though again, their development projects and consortia are mainly outside the regional context. These developments are in particular very interesting since they indicate that the region is also benefiting from a global value chain development.

Finally, between 2015-2018 horizontal launch and spaceport developers based at Prestwick Airport, as well as other spaceport consortia have been emerging, though they are more akin to local government groups than industry players. These consortia have received a significant boost lately through recent Industrial strategy funding, as the UK Space Agency has now provided £31.5m for the establishment of vertical launch capability in Sutherland (NW Scotland) (UK Space Agency, 2018a). However, it is not clear if the £2.5m dedicated to ground infrastructure will be sufficient to get the project off the ground, and contenders such as the island of Unst in Shetland archipelago as well as North Uist in the Western Isles are proposing to develop their own independent capabilities (*BBC News*, 2019; Shetland Space Centre, 2019).

In order to characterise the economic effect of these clusters as well as the overall level of economic maturity across the sector, I have also analysed business formation and capitalisation. In particular, looking at the spread of current business interests across the sector, one can clearly see that there has been a significant amount of proliferation and institutionalisation, typical of sectors in conclusion of their emergence phase (Déjean, Gond and Leca, 2004). Looking at the development of SMEs segment of the sector, which is the object of this research and where most of this growth is happening, our research shows that the number of core firms has jumped from about 5 in 2002 to approx. 10 in 2007, 15 in 2012 and 20 in 2017. Recently, we have also seen the first investors exit the start-ups, with a £26 million merger of Clyde Space, one of the sector's primes, with a Swiss partner AAC Microtec (Dorsey, 2017). In comparison to the Veripos and Optocap acquisitions which took place in the more traditional and mature Space Sector markets, this merger was on a more equal footing as far as relative size and history of the two players and might be a precursor to the formation of a new multinational corporation, independent of longstanding space industry primes.

There has also recently been a series of inward investments, for instance, the establishment of an office and manufacturing facility for a fast-growing US-originating SME Spire, which worked closely with Clyde Space to carry out their first batch of R&D, before moving on to in-house R&D and production. This level of international recognition and economic maturity likely marks the endpoint of the early (development) stage of the sector. Furthermore, many firms are now at the stage to end serial R&D projects and move to productisation, manufacturing standardisation and shifting focus from radical innovation to a more incremental one. In many ways, due to the structure of the global market as well as the nature of products and their customers, the key monetisation of the past investment is through exports, though the latter is so far limited to government backed-programmes in the UK and abroad, such as the downstream International Partnership Programme (Ecometrica, 2017; Murden, 2017).

Overall, the described dispersed and divergent nature of the “Space Glen” SMEs does little to explain Scotland’s ability to project the joined-up view of a distinct emergent sector, though it underpins the critical importance of research-business partnering in innovation, as one of the main reasons for clustering. However, how has this been mobilised to create a globally recognised regionally-based sector?

Community Angle: Creating a Joint Vision of a “Space Glen”

I propose that the crucial development within the sector is its consolidation based on a creation of a shared sensemaking, which is done through establishing a joint vision for a "brand" identity, such as the "Space Glen" (*Business Insider*, 2018), building on previous well-known "Silicon Glen" framing of Scottish electronics industry (Wilson, 2019), itself modelled on Silicon Valley (Haug, 1986). Though different names are also used near synonymously, for instance, the more abstract and generic "Agile Space" discussed later, it is the parallel with the past ambitions for a global high-tech value chain powerhouse that make "Space Glen" a particularly evocative label for the emerging Scottish New Space Sector. In particular, I argue that this regional-sectoral identity development is coordinated through shared spaces, especially through conferences and events – by having joint Scottish representation, announcing major ideas and/or policies and by hosting them in Scotland to showcase local capabilities as in presented in this section.

Scotland has in recent years (2000-2017) attracted some of the largest international space conferences, with focus on space science, engineering and business. Most notably, in 2008 Glasgow hosted the International Astronautical Congress, the largest and most prestigious conference in the sector. It occurs annually and is often marked by landmark national and regional developments, for instance, the establishment of UK Space Agency was announced as well as UK joining ESA manned space exploration programmes (completed in 2010). Similarly, Edinburgh hosted the European Space Agency's Living Planet Symposium in 2013, focused on the development of Planetary Science and Earth Observation. Attracting about 1700 delegates from around the world it "*[brought] together scientists and users from across the globe to present their latest findings on Earth's environment and climate derived from satellite data*." (ESA, 2013) These conferences gave a substantial boost to the relevant scientific communities and brought attention to the local Scottish dimensions of the global Space Sector. In the years since these major events were hosted in Scotland, the Scottish Enterprise in partnership with other key agencies, UK Space Agency in particular, also secured joint Scottish representation at their subsequent international locations.

Scotland also recently hosted a series of specialist conferences about the use of optical systems in Astronomy and Satellite/Space Data Applications, organised by the International Society for Optics and Photonics (SPIE). There were SPIE Astronomical Telescopes + Instrumentation as well as SPIE Security + Defence and Remote Sensing (the latter two are always taking place at the same location at the same time), all hosted in Edinburgh in 2016. These conferences are quite focused and it is important to note the significance of the topics coalescing around themes of astronomy and space science and engineering, predominantly focused on optics. Scotland being a recent host and local organising committees including leading scientists and engineers from the region helped establish it in a position of global leadership within the scientific and engineering community. In the latter category, more targeted and less international events provide development opportunities and much more accurately demonstrate the innovation potential within the region and showcase its activities. For instance, the hosting of the 2013 UK Space Conference in Glasgow marked the beginning of the end of the first, constitutive phase of the sector's emergence. At the subsequent 2015 and 2017 conferences, the Scottish New Space Sector was jointly showcased under the Scottish Enterprise coordination and sponsorship. Furthermore, Glasgow was host to a series of other leading events, such as the British Interplanetary Society’s Reinventing Space conference in October 2017. Though smaller in size than the UK Space Conference, it has a specific focus on New Space development both in the upstream as well as downstream part of the sector, including site tour of a leading Glasgow based New Space upstream firm, Spire. It also featured the re-launch of the British Interplanetary Society’s Scotland regional branch (Vidmar, Davies and Patterson, 2019).

The Scottish Space sector is also establishing its own events, primarily through the leadership of Scottish Centre for Excellence in Satellite Applications (SoXA), who run a very successful series of Scottish Space Symposia, in partnership with several other actors in the sector (*1st Scottish Space Symposium - University of Strathclyde*, 2010). 2017 saw the inauguration of Data.SPACE conference hosted annually in Glasgow, which aims at establishing Scotland as a leading player in Space Data applications globally. Such capability is underpinned by a critical mass of past activity as well as an ecosystem of players interested in developing a common vision for the sector in the region. For instance, at the inaugural Data.SPACE conference in 2017, two leading Scottish New Space Sector SMEs, announced the creation of a conceptual integration of the Scottish New Space value chain, in a grouping called “Agile Space”. The vision behind this proposal, put forward by the lead upstream satellite manufacturers Clyde Space and largest downstream data analytics company Ecometrica, was to exploit the fragmented nature of the sector and from an “informal grouping open to companies and research organisations operating in Scotland” to collaborate on “specific market opportunities”, “develop funding and support models” and to “ensure seamless operation and communication of key messages” (‘Agile Space Group - Scotland: Home of Agile Space’, 2017). In particular, it seems that the key message of the Agile Space Group was that:

"Scotland's space industries and research institutions could benefit by promoting Scotland as Home of Agile Space. By emphasising this strength we can attract inward investment and talent, and promote the creation of a vibrant technology and service ecosystem leading to high value technology and service exports." ('Agile Space Group - Scotland: Home of Agile Space', 2017)

These events and the initiatives developed through them also get sporadically picked up in the media, though primarily for either a UK audience (such as the BBC and the UK and Scottish broadsheets) or within very specialised outfits (such as business magazines). Though these reports clearly reinforce the narrative of a collective Scottish New Space brand, whether it being "Space Glen", "Agile Space" or specifically the city of Glasgow's satellite manufacturing records, they by and large repeat the messages produced by leaflets and press releases at these events and do not in themselves constitute new perspectives or analysis. Hence, in order to further advance the understanding of the consolidation of the Scottish New Space economy, the practitioners' views of the political drivers and on the ground configuration is needed. In the next section, these are analysed using primary data from interviewing a select small group of informants from across the sector.

Critique: Stakeholder's Perspectives and the Future of "Space Glen"

The dominance of the two main conflicting perspectives outlined above, i.e. the unified innovation policy targets and interventions and the dispersed, fragmented nature of the sector, meant that the main thrust of my interest in understanding the stakeholders perspective of the "Space Glen" development was in comparing and contrasting these two conflicting framings.

The Politics of Numbers and Targets

To begin with, the interviewees' observations confirmed this "common wisdom" about the industry being fragmented, commercialised and, at least in terms of the turnover dominated by satellite TV provider(s). Explicitly, a business development manager at one of the universities commented:

“The problem with the Space sector is that a lot of it is smoke and mirrors. […] When you talk about a £10bn-a-year Space sector, £5bn of that is Sky [satellite TV provider]. […]” (Interview B)

This consequently raises a concern about the implications for the current policy setting ambitious growth targets. The same interviewee immediately commented *“where are you going to find another two or three “Sky-s”?”* Similarly, another interviewee, also a business development manager, but based at a national research laboratory, remarked that the current updated data showing the targets at the moment are being met is potentially misleading as

“they are not looking at linear growth up to 2030, the growth rockets at some point, and you go: “Oh, ah well!” [shrugs and rolls his eyes]” (Interview C)

This latter comment clearly shows that the interviewee is unconvinced that the methods employed to project future growth are realistic; rather that there is some potential of “massaging the numbers” being deployed. However, this is not to say they consider targets as unimportant: all interviewees argued that there is strong evidence on the ground, specifically mentioning conferences as the venues where that can be noticed, that the policy framework and a sense of optimism regarding the growth trajectory are electrifying the sector, both within the academia, as well as with the entrepreneurs. On this topic, the same interviewee specifically commented:

“It is not whether you hit the target that counts; what counts is how much of an impact you make, how much growth you actually get and if you turn that into viable industries. If it turns out that we end up with 9.5% or 9% of the World market in Space by 2030, that is still bloody good! […] The target is just something to aim for.” (Interview C)

Interestingly, they also believe that the targets, or something close to that outcome, is achievable, in particular in the case of Scotland, as the conditions here are more favourable in their view:

“I think it will [work] […] <u>because</u> [emphasised by the interviewee] of these differences [with the rest of UK]. Scotland, as far as I understand, has a larger relative manufacturing sector than the UK as a whole, and

also there is still a lot of memory of a proud engineering heritage in Scotland [...]. There are also […] industries that currently exist in Scotland like the Oil and Gas, for example, who are potentially very good markets for downstream [Space] applications […]" (Interview C)

Though they recognise the Scottish New Space Sector's dispersed and divergent configuration, they by-and-large believe that such dispersed clustering is an advantage, as the SMEs are embedded less in a "Space Sector" grouping context and more in research/industrial groupings with existing commercial applications, which have shorter paths to market. The scoping here clearly pointed at a specific structural feature, which merits further investigation. How do such views marry with the overarching loose value chain integration, as we have seen in the case of the emergent "Agile Space" group? And how is such integration actually playing out in support of innovation within SMEs? Answering these questions will illuminate the structural configuration of innovation systems and processes within an emergent sector.

In contrast with the positive view of the targets, most interviewees were very critical of the overall UK policy with respect to not providing systemic growth-oriented funding schemes. The key problem they foresee for future growth is access to finance for firms just outgrowing the SME size – they commented on the lack of venture capital investment for "scaling-up" and noted that:

"[…] the UK wants to grow SMEs and then sell; USA wants to build multinationals!" (Interview C)

This was also mentioned by the interviewees in relation to establishing new firms requiring significant capital investment to begin with, in particular, for example, related to launch capabilities. This has been somewhat rectified very recently with the investment in spaceports in Scotland (Knapp, 2018), though the location and small size of the infrastructural investment have been criticised (*Last week's poll: what do you think of the UK spaceport plan*, 2018). Overall, the dispersed small-scale investment through R&D and commercialisation grants, which is recognised as key UK / Scottish policy intervention in the sector was described in several comments having relied upon the "low hanging fruit", which has now been collected and from now on it will get harder to grow and develop the sector to meet the targets.

Bringing it all Together?

What are the informants' views on how to reconcile the unifying policy ambition and the dispersed state of the ecosystem? Informants suggested business strategies in the Space Sector are similar to those used in other areas of high-tech industries, with the primary focus being on securing financial resources and business expertise. As expressed by one of the early-stage business development managers, coordinating UK-wide programmes, this is based on their belief that the

> *"… premise of technology transfer from Space is not about necessarily having a Space Industry to base it on, [rather it] is having entrepreneurs looking for technology, and Space has always been a driver for innovation." (Interview A)*

This is an important lead for future research to build a deeper understanding of the "Space Glen's" evolution as well as in the sector moving towards the next stage(s) through a new set of policy interventions. For instance, very recently dedicated space-specific incubation and business development/support programmes have emerged, such as the STFC's Higgs Centre for Innovation (STFC, 2013) and SoXA's Space Incubator at Tontine (Tontine, 2018), though there are already many other (non-Space focused) technology incubators in Scotland, in particular in Edinburgh. With respect to implementing the innovation policy on the ground, one interviewee touched upon the importance of educating the SMEs in business development whilst still in the early stages, and another mention the need to provide a (more) tailored support depending on each of their circumstances.

However, interviewees broadly agree that the sector's long term challenges are related to access to further capital investment, appropriate recruitment, and the establishment of business networks leading to markets. In many ways, all three of the above depend on the primary network the company has in terms of finding support for its creation and development, which bring about the need to understand these networks and how they influence the process of innovation. This is a key point to understand how the innovation ecosystem works and indeed how to support it going forward, as one of the business development executives within an SME specifically commented:

"Key for success [in the early-stage enterprise] is having some key contacts, who can help you open the doors to the industry […]"

(Interview D)

In line with the strong feeling about the importance of the networking, they also commented that it is often felt that the Space Sector is a bit of "an old boys club" of (large, international) established firms, hence connections are crucial to break into the market or open up a niche, though to do so SMEs need "to gain credibility in the market". Here, the establishment of new branding, be it "Space Glen" or the "Agile Space" may be helpful, as well as direct certification or approval by association from established "traditional" Space Sector players, in particular, the European Space Agency and NASA, though the latter requires firms to have USA presence (subsidiary), before directly engaging with them[13].

Overall, the qualitative data supports my earlier analysis that the space innovation policy pursued in UK and Scotland is being accepted by the stakeholders as an opportunity for further sectoral development, though they are critical of the targets themselves and methods employed to achieve them. In particular, the current policy delivery method of small-scale dispersed R&D investment is seen as insufficient for growing the SMEs into larger corporations and innovation in more difficult and complex technology areas requiring significant upfront capital. This is seen as a critical way forward, in combination with the development of a united sectoral identity through networking, though keeping the SMEs in current clusters close to target non-Space applications markets, to ensure easy access to those. These ideas spell a new approach for innovation, which seems to derive from a looser eco-systemic view of value chain integration, as advocated in the "Agile Space" approach. However, the questions emerge how this leads to new product development and growth of economic activity, and what the role is for innovation policy interventions, most often through intermediaries.

Conclusions and Further Research

This paper outlined the Scottish perspective on the global trends of the emergence of the New Space Sector and in particular, its integration in industry-led innovation policy and the

[13] In addition, USA Government policy treats Space Sector as a critical national asset and regulate export of space technologies under International Traffic in Arms Regulations – making flow of people and knowledge difficult, even though a relaxing of this regime has been proposed (Cornell, 2011).

economic trends on which developmental targets are made. In particular, it traced the main reasons behind the hands-off free-market approach to the Space Sector, which has a longstanding history in the UK. It combines small-scale dispersed governmental R&D investment with support for sector building through business development delivered through a series of innovation intermediaries. I have argued/shown how this is reinforced in Scotland with an additional regional impetus by the Scottish Government to diversify the Scottish economy and build a distinctive Scottish industrial base.

Furthermore, by analysing the structural configuration of the New Space Sector in Scotland, I identified three distinct research-linked clusters. To integrate them in a joint vision of a Scottish “Space Glen” I propose that the idea of a unified Scottish Space Sector was put forward through a series of international and national conferences and events. At those events, Scottish SMEs were jointly represented and new ideas about their collaboration and loose value chain integration were presented. In particular, a critical moment was the “Agile Space” framing proposed at Data.SPACE 2017 by the leading upstream and downstream players. However, when contrasting these policy and structural observations with views from practitioners, several (upcoming) challenges were addressed, though there was overall agreement on the significance of the opportunities presented in the sector as well as approval for policy ambition as a vehicle to energise the stakeholders. The distinct clustering of SMEs within the sector was noted as a strength since their embeddedness in other local sectoral ecosystems shortens the path to market for applications derived from the space sector, which is an asset for a nascent value chain.

However, the analysis presented here is incomplete and new questions are emerging regarding the relationship between the political and economic developments and the actual processes of innovation. Being a scoping study, it only covers the preliminary insights and is limited to secondary data and broad ethnographic observation, with a small number of semi-structured interviews. In terms of new research questions, two are standing out in particular - what is the fundamental link between these new narratives and modes of innovation, i.e. the “Agile Space”, and development of new products and services in the emergent Scottish Space Sector? And how is innovation actually realised through the “Space Glen’s” Agile Space framing? In order to understand the “Space Glen’s” emerging New Space economy, and how developments in Scotland can be understood in the global context, these questions need a more detailed answering.

Annex 1: Space Industry Events Attended and Site Visits

1. Living Planet Symposium, Edinburgh (September 2013)[14]
2. Satellite Applications Catapult Symposium, Glasgow (January 2015)
3. The Future of UK Space Industry, London (January 2015)
4. 3rd Scottish Space Symposium, Edinburgh (April 2015)
5. Site Visit to Harwell, Oxfordshire (May 2015)
6. GLIC + SpaceUP, Munich (June 2015)
7. UK Space Conference 2015, Liverpool (July 2015)
8. Reinventing Space 2015, Oxford (November 2015)
9. SUPA Cormack Meeting, Edinburgh (November 2015)
10. Appleton Space Conference, Oxford (December 2015)
11. National Students Space Conference 2016, Sheffield (March 2016)
12. Space Technology Congress, London (April 2016)
13. GLIS + SpaceUp, Geneva (June 2016)
14. SPIE Astronomical Instruments Conference, Edinburgh (June 2016)
15. Site Visit to Guildford, Surrey (September 2016)
16. SPIE Space + Defence and Remote Sensing, Edinburgh (September 2016)
17. Reinventing Space 2016 + Site visit to Stevenage, London (October 2016)
18. SpaceUp Manchester + Site Visit to Daresbury, Manchester (November 2016)
19. Data.Space 2017, Glasgow (February 2017)
20. Manifest Destiny (Mars Symposium), Edinburgh (February 2017)
21. National Students Space Conference 2017, Exeter (March 2017)
22. UK Space Conference 2017, Manchester (May 2017)
23. SpaceUp London (June 2017)
24. Space Traffic Management Workshop, Edinburgh (August 2017)
25. Space Generation Congress 2017 + International Astronautical Congress 2017, Adelaide (October 2017)
26. Reinventing Space 2017 + Careers Day, Glasgow (October 2017)
27. Next Generation Space Mentoring & Networking Event, Harwell (November 2017)
28. Data.Space 2018, Glasgow (January 2018)
29. The Space Age: A Global Revolution at International Business Forum 2019, Liverpool (June 2018)
30. International Astronautical Congress 2018, Bremen (October 2018)
31. SpaceUP Leicester (October 2018)
32. Reinventing Space 2018 + Careers Launch, London (October 2018)
33. Planetary Environment in a Lab Workshop, Stirling (February 2019)
34. National Student Space Conference 2019, Edinburgh (March 2019)
35. WIA-E UK - Filling the skills gap in Scottish Aerospace, Edinburgh (March 2019)
36. National Physics Laboratory Space Technology and Measurements Meeting, Edinburgh (April 2019)
37. 4th European Space Generation Workshop, London (May 2019)
38. Future Skies Workshop, Oxford (June 2019)

[14] I attended this conference before starting this research.

39. Scottish Space Symposium (June 2019)
40. Preparing for Space 19+ and developing the National Space Programme workshop, Edinburgh (July 2019)
41. SpaceUP Glasgow (July 2019)
42. Space Traffic Management Workshop 2019, Edinburgh (August 2019)
43. Space Generation Congress 2019 + Space4Earth Hackathon + International Astronautical Congress 2019, Washington, D.C. (October 2019)
44. Reinventing Space 2019 + Careers Day, Belfast (November 2019)
45. Scotland: The Next Frontier, Edinburgh (November 2019)
46. SpaceUP Leicester (November 2019)

Chapter 2: Agile Space Living Lab – The Emergence of a New High-Tech Innovation Paradigm

Introduction – "Living Labs" and "Agile Space"

Over the past 10 years (2008-2018), Scotland has emerged as a global leader in the New Space Industry (Macdonald, 2017, 2019), in particular in nano-sat platform development and space-data driven applications (Scottish Enterprise, 2016a). The way in which such advantage was attained is of significant interest in understanding socio-economic and scientific context, which, coupled with changes to innovation practices and specific policy interventions, can bring about a transformational change within the sectoral and regional business ecosystem. This is of broad interest in theorising the factors influencing economic development, as well as proposing a structural framework supporting SMEs in high-tech innovation.

Hence, this paper is outlining the current state of the Scottish Space Sector in the context of the crucial development of the Space Industry in the UK and globally – the transition into the 3rd generation or "New Space" era (Adlen, 2011). In particular, I am examining the way in which the Scottish Space Sector SMEs are interacting with the environment, which is enabling them to co-develop the emerging technologies and markets. This analysis is based on evidence from a detailed analysis of secondary data, in particular, comparative document analysis (Bryman, 2016), as well as original ethnographic work through interviews with professionals (Platt, 1981) (SMEs' CEOs or CTOs) and social network analysis (Scott, 1988; Giuliani, 2007a), all completed between 2014-2017. The qualitative work presented here is centred on a structural analysis of qualitative data based on a small set of typical cases (Yin, 2009), though I examined all core Scottish Space Sector SMEs identified through extensive participatory engagement (McIntyre, 2007) with the sector.

Through this analytical work, I propose that by applying the recently emerging conceptualisation of living laboratories (or Living Labs) (Følstad, 2008; Bergvall-Kåreborn *et al.*, 2009; Almirall, Lee and Wareham, 2012; Leminen, Westerlund and Nyström, 2012; Dell'Era and Landoni, 2014; ENLL - European Network of Living Labs, 2019), Scotland can be framed as an ideal test-bed for a variety of space/satellite applications, due to its mature scientific and R&D ecosystem and infrastructure, combined with a diverse natural environment, highly-skilled workforce and significant early-adopters/lead-users community. Hence, I propose that the Living Labs approach to sectoral development, coupled with a loose vertical value chain integration proposed by the industry itself – something many Scottish players refer to as “the Agile Space” (Harris, 2018)- is paving the way for a new business and innovation approach.

Based on my original analysis using new empirical data, I specifically argue that the crucial difference in the form of the innovation process between the traditional Space SMEs and the “new Space” ones, can be characterised as the structured and formalised new product development model including a local network of interdisciplinary stakeholders, mainly from the public sphere. Such an approach to innovation is clearly related to the conceptualisation of the Living Labs open innovation model. Furthermore, based on the main findings of this work, I propose a future research agenda for a detailed analysis of the mechanics of these high-tech innovation processes, the emergence of structural linkages across the sector, and the role of innovation intermediaries in its development.

This paper begins by reviewing the two key concepts: on one hand, the “Living Laboratories” conceptualisation of emerging open innovation systems framework, and other the other hand, cross-sectoral linking and a new form or vertical value chain integration within the New Space Sector in Scotland, termed “Agile Space”. Then, I outline through empirical data how downstream Scottish Space Industry effectively deploys the Living Labs approach, illuminating some of the key elements and effects of the combined Agile Space Living Labs approach through innovation networks mapping, qualitative analysis of new product development processes and a specific application case study. Finally, I turn to the substantial leads for further research, which can deepen our understanding of this emerging innovation paradigm.

“Real World” Innovation and Living Labs

A new understanding of systemic changes in high-tech innovation has occurred with the emergence of Living Laboratories or Living labs conceptualisation (Feurstein *et al.*, 2008; Følstad, 2008; Bergvall-Kåreborn *et al.*, 2009; Kareborn and Stahlbrost, 2009; Almirall, Lee and Wareham, 2012; Edwards-Schachter, Matti and Alcántara, 2012; Dell’Era and Landoni, 2014). In particular, this concept outlines the practical configuration of the innovation processes as they break away from the traditional association of high-tech R&D with a technology-push dominated product development, i.e. that technology developers come up with new solutions first and only later look for what demand/need might they be targeting to bring the technology to market (Di Stefano, Gambardella and Verona, 2012). Such "linear flow of innovation" within these "technology-push" models is associated with technological determinism, which is persistent, even though they have been analytically discredited (Godin, 2006). The gist of these approaches is underlining the development of the technology itself as the primary concern in innovation studies and presuming a one-directional "progress" from innovator's ideas, through the development process and towards the user.

However, such view of innovation process has been severely criticised, by the more inclusive systems-based approach, acknowledging the "fuzzy" or "messy" nature of the activities leading to the emergence of (successful) new products (Chidamber and Kon, 1994). In particular, a crucial role of external actors in the context of the innovation organisation has been highlighted, in particular in terms of acquiring knowledge, expertise and other resources from research institutions and other sources, as well as involving users in the process of development (von Hippel, 2009; West and Bogers, 2014). Such a view is embedded in the analysis of "open innovation", i.e. innovation process crossing firms' boundaries (Chesbrough, 2006; Lee *et al.*, 2010), "innovation systems", i.e. the necessary capacity for innovation being a product of a larger system involving different actors and linkages (Freeman, 1991; Cooke, 2001; Malerba, 2002; Hekkert *et al.*, 2007), and "innofusion" and "social learning", i.e. the crucial role of users and user groups in innovation (Fleck, 1993; Hyysalo and Stewart, 2008).

All of the above suggests the process of innovation is highly interdependent on its localisation and social/economic/political/etc. context. The Living Laboratories innovation framework, originally emerging from the information technologies sector, also follows these new principles of "open", "systemic" and "social" R&D, in particular by stressing the coordination between innovators and (lead) users (Bergvall-Kåreborn *et al.*, 2009), with the interaction having evolved from "consumption" of innovation to "co-creation" (Edwards-Schachter, Matti and Alcántara, 2012). The crucial premise behind the Living Labs model is the systemic interconnectedness of all actors within a bound (most often geographical) unit or activity, thus creating a "living R&D laboratory" (Dell'Era and Landoni, 2014).

A specific geographical and sectoral focus is also significant in terms of aligning with the understanding of localised economic development initiatives. Specifically, there is growing importance being placed on the development of regional competitive advantage in order to successfully perform in the global economic system(s) (Tallman *et al.*, 2004), such as through the European initiatives for (regional) Smart Specialisation Strategy (Mccann and Ortega-argilés, 2017). The smart specialisation policy framework is built around a (regional) economic development theory, in particular, the presumed need for regional competitive advantage in order to successfully perform in the globalised economic system (Tallman *et al.*, 2004). At its core is a crucial reliance upon fostering innovation system, in order to develop a "related variety" of research, industry and entrepreneurial activities, resulting by the region becoming a global leader within a specific sector of economic activity (David, Foray and Hall, 2013).

Some of these "laboratories" can be very small and erratic, such as an individual classroom in a school, though on the other hand, the largest Living Labs can extend to encapsulate vast international areas, such as the coast of North Sea. Conversely, the "construction" of these "laboratories" is more often than not very project-specific, i.e. it depends on the sector or group of technologies developed as to what relevant actors and geographical boundaries are most applicable. Though these are sometimes deliberately configured in advance, they are often more clearly recognised or "discovered" only within contemporary or historical analytical work. Here, by recognising their dual political and phenomenological nature, and by bringing together the leading conceptual definitions, methodologies and modalities of Living Labs, I propose to establish a set of contextual identifiers which can be used to characterise emerging innovation practices as part of the Living Lab conceptual framework. In doing so, I hope to establish a clear analytical framework with which I can examine the emerging features of emerging high-tech innovation ecosystems, in particular, the critical example before me, the New Space Sector in Scotland.

Context Identifiers for "Discovering" Living Labs

Though Living Labs label originates from practitioners in innovation management and public policy arena, it has featured in several analyses of new modes of innovation in innovation and entrepreneurship literature (Levén and Holmström, 2008; Almirall, Lee and Wareham, 2012). Of particular importance here is the involvement of (lead) users in identifying and creating demand for new solutions and in designing and testing products and services to satisfy these needs (Almirall and Wareham, 2008). Hence, this framework moves beyond the typical clustering or (eco)systemic analysis of relevant firms and institutions supporting innovation, by noting the roles performed by actors other than business and research organisations and crucially, by more directly addressing the role of (natural and social) environment in the development process.

Furthermore, the Living Laboratories paradigm resonates strongly with an observation by science and technology scholars, who have long argued that in order to launch successful transformative technologies into society, it is the “outside world” that has to become more akin to the physical and social environment within the laboratory (Latour, 1983, 1988). In order for such an endeavour to work, not only has the scientific and technological development be supplemented by political and social capital to achieve societal recognition and acceptance, but the proposed solution has to be credible and made to resonate amongst the society as a way to frame and address an existing acute challenge.

Hence, in the current knowledge/data-driven economy and noting the current “grand societal challenges” (Kuhlmann and Rip, 2016), mainly related to global ecology, the construction of Living Laboratories-type innovation processes to deploy new technological solution into the society is a continuation of a long-established tradition of science’s “enrolment” of other actors (Callon, 1984), both within the natural context, as well as within the social one, into new instances of epistemic ordering. The Living Labs framework can be seen as making these crucial elements of the innovation process, and their alignment within and outwith organisations engaging in innovation, an explicit and central feature. In particular, it postulates the interdependency of natural and social elements within an “innovation ecosystem”, i.e. linking appropriate access to the natural environment with societal structures such as a mature scientific and R&D ecosystem and infrastructure.

European Network of Living Labs Conceptualisation (Edwards-Schachter, Matti and Alcántara, 2012; ENLL - European Network of Living Labs, 2019)	**Living Lab User Involvement Methodologies** (Almirall, Lee and Wareham, 2012)	**Key Components of a Living lab** (Kareborn and Stahlbrost, 2009)	***Proposed Enabling Contexts for a Living Lab***	***Scotland***
Multi-stakeholder Participation	User Centred	Partners	*Geographically, Politically and Economically Bounded*	✓
			Appropriate Scale and Size	✓
Real-life Setting	Design Driven	Application Environment	*Diverse Natural Environment*	✓
		Technology and Infrastructure	*Physical and Digital Infrastructure*	✓
Multi-method Approach		Organisation and Methods	*Research Capabilities*	✓
Co-creation	Participatory	User	*Highly Skilled and Educated Workforce and Community*	✓
Active User Involvement	User Driven			✓

Table 2 – The proposed set of Living Labs framework contextual identifiers and their presence in Scotland. By cross-matching the key leading conceptual definitions, methodologies and component modalities of Living Labs, specific practical enabling contexts are proposed. These can serve as normative suggestions for the construction of new Living Labs or analytical identifiers for "discovered" ones.

Specifically, I propose that by intersecting the key concepts within the Living Lab framework with its key methodologies and components a new model emerges whereby one can identify a de facto living lab from the presence of its contextual enabling factors. I propose these to be Geographical, Political and Economical Boundedness, Appropriate Scale and Size, Diverse Natural Environment, Physical and Digital Infrastructure, Research Capabilities, and Highly Skilled and Educated Workforce and Community. This is based on recognising that the bases of these identifiable "real-life" contexts are rooted in framing and inclusion, settings and technologies, and engagement of users (Kareborn and Stahlbrost, 2009; Almirall, Lee and Wareham, 2012; Edwards-Schachter, Matti and Alcántara, 2012; ENLL - European Network of Living Labs, 2019). This conceptual derivation of these factors, and their presence in Scotland, is outlined in Table 2.

Hence, by identifying these elements within any innovation grouping, which is attempting a functional consolidation, such grouping can be recognised as a Living Lab. This is also consistent with the pivotal definition of Living Labs as “methodology aimed at co-creating innovation through the involvement of aware users in a real-life setting” (Dell’Era and Landoni, 2014). Therefore, having outlined the Living Lab conceptualisation, its importance for the understanding of the current innovation contexts, I return my attention to the New Space Sector. In particular, I will outline in the next section its emergence in Scotland and the set-up of the “Agile Space” approach to innovation and sectoral development. Following from the framing of “discovered” Living Labs outlined above, I will also link some of its key elements to the derived contextual identifiers.

The Making of “Agile Space”: Space Sector in the UK and Scotland

The Space Sector is currently in a major industry transition from Space 2.0 to Space 3.0 (i.e. into “New Space”) (Adlen, 2011). Though as before the markets are built around the three main areas of applications: Earth Observation (EO), (satellite) navigation and telecommunications/broadcasting, the significant amount of growth in this area and the increasing economic and political value and importance emerged on the back of cheaper core technology (electronics, hardware, 3D printing), open source data (from public programmes, such as ESA/EU’s Copernicus) and new system/operation solutions (e.g. cloud-based platforms for operation and data management). These developments enabled new entrants to the market to emerge from traditionally peripheral geographies, such as Scotland.

Importantly, the UK space industry was in many ways the key for the transition between the 1st and the 2nd phase/generation as the UK was the first country to commercialise its launch capability (Willetts, 2013). Furthermore, due to the leading role of UK in commercialising space applications, for instance, the dominance of UK-based BSkyB in satellite (TV) broadcasting (Willetts, 2013), it is hoped that the UK can capitalise on similar leadership in the current transition. This is further encouraged through the support for innovation as a means to capitalise on the UK’s pole position in research in (basic) science and engineering (Autio, 2014). Hence, the political interest in generating economic and societal impact from the continuous development of the Space Sector is unsurprising. However, in the UK, and perhaps even more specifically in Scotland, the conditions surrounding this development are of particular interest in understanding the process of innovation in a highly specialised industry such as the Space Sector.

The overall development of the sector in the UK is crucially framed by the Space IGS vision and action plans (Space IGS, 2011, 2014) which provide detailed development agenda, and by the “economic case” presented in the “Case for Space” reports (London Economics, 2009, 2015b). Since 1992 the industry is also monitored in the biannual “The Size and Health of UK Space Industry” survey (Oxford Economics, 2010, 2012; London Economics, 2014, 2016, 2019), which is the basis for the Case for Space reports (discontinued in 2017) and have now become the baseline to evaluate the performance of the overall development strategy. Specifically, this government-backed policy aims to an increase of the UK share of the global space industry market from 7% to 10% by 2030 (Space IGS, 2011, 2014; Willetts, 2013), worth £40bn out of the predicted £400bn total. Similarly, Scottish Enterprise acting on behalf of the Scottish Government (under UK devolution) has the ambition to see 10% of that economic activity based in Scotland (London Economics, 2015a; Scottish Enterprise, 2016a).

The critical component of these policies and ambitions is their reliance on the development of new enterprises (SMEs) through an improved entrepreneurial climate and incentives for knowledge transfer from basic and applied research and demand-driven innovation. This approach is related to two key phenomena. Firstly, the New Space transformation is still limited in the valorisation of its markets and producing the promised turnovers. This observation is particularly applicable to the more radical technological innovations and new products aimed at individual consumers. Until a clearer market opportunity is proven, the larger companies are less interested to enter this arena. Secondly, by and large, the New Space innovations are not competing with "classical" or "traditional" space products, but rather complement and extend the space domain reach.

Not only there is little competition with traditional space actors, these new products in fact still rely on continued investment in classical space. For example, nano-satellite platforms currently still predominantly rely upon spare capacity in bigger projects for space launch. Furthermore, big geostationary navigation systems are used by nano-satellite for flight control. In the downstream segment, most of the new applications are being developed using data from (open source) Earth Observation satellites, which, particularly the more complex radar-based systems, are results of public investment and produced by "classical" space actors. This status quo, which enables SMEs relatively uninterrupted development of new products and markets, may not hold for long, though. In particular, nano-satellite proliferation is likely leading to certain services offered by new space players surpassing the larger firms' offerings. Hence, a shift in bigger players attitude has already been seen in some pivotal key global cases such as the provision of global internet coverage. Whilst this was initiated as a "new space idea", underpinned by the increasing availability of large constellations of smaller (and cheaper) satellites, the key developers, a group called One Web, have been subsumed as a venture between some of the largest global space firms (namely Airbus, their subsidiary Ariane Group/Arianespace and Virgin Galactic). Crucially, this enabled input of capital (including a $1.2bn investment) and political leverage for the project (Caleb, 2016), its transformative potential for an ecosystem of smaller businesses (a central premise of the New Space transition) did not (yet) manifest once these bigger firms took over.

The Configuration of Players Within the Scottish Space Sector

In the context of the global industry transition to "New Space" and the increased political and economic interest in these activities in the UK, Scotland is an interesting case study to analyse these emerging trends. Specifically, even though the space industry in the UK has been a strong sector for a long time, this was mainly centred on the South-East, particularly Surrey and Oxfordshire, and Scotland was mainly left out. One of the factors for the emerging prominence of the Space Sector in Scotland may be related to Scotland's Government political ambition over the past decade to create high added-value sectors (The Scottish Government, 2013). In particular, this was done in order to diversify from the traditional dominance of oil and gas, financial services and tourism in the Scottish economy, whilst at the same time build upon the traditional engineering skill base. This framing presents the clear geographical, political and economic boundary, which can be seen as the initial core factors in the establishment of a Living Lab innovation process.

However, the kind of sustained big-scale investment as seen in the renewables sector was not directed towards the Space Industry and most funding projects in this area are led by the UK government. In contrast, Scotland has invested more in networking efforts, with over £200k investment in establishing an integrated network of space-related activities (Vass, 2013) and including space as one of the key sectors supporting the creation of innovation generating initiatives, within the Living Labs framework (The Scottish Government, 2013).

The aim is to join up-sectors with common interests, in particular, space-data based Geosciences/Earth Observation and the energy sector, both in fossil fuels as well as renewables, promoted in particular through partnerships with NERC and Satellite Applications Catapult's Scottish Centre for Excellence.

The industry attitude towards this analysis and the development plans were examined between 2014 and 2018 based on qualitative data collected through a small series of targeted semi-structured interviews. This qualitative data shows that the Scottish Space Sector is enabled by a strong R&D cooperation, including cross-disciplinary links with academia, due to the specific "city campus" University environment. This is particularly important for network mediated knowledge transfer by attracting non-space and non-technical partners into Space Sector projects. This is in line with a comment by a space SME CTO interviewed about the importance of non-space actors for the kinds of products they develop. He explicitly mentioned:

> *"When I go to a space cluster there is a lot of companies clustered together, but it is just high-tech […]. I think what Scotland needs to champion is the idea that our Space Industry is embedded in larger entities – which is the cities. […] I think what space needs to do is to move out of the Space Industry and into these other sectors and I don't think that is something you can do in a campus environment […], it needs to be in a city environment where they are surrounded by other non-related sectors."*

Scottish cities, due to their highly educated workforce and good provision of facilities and services are commonly seen as an asset for developing and growing high-tech clusters, for example, biotech (Leibovitz, 2004). Hence, there is a strong indication from my research, that it is precisely this historic make-up of the Scottish academic system that makes a key contributing factor for the significant uptake and rapid growth of the "New Space" sector in Scotland, as innovators can make direct and varied linkages to cutting-edge research as well as contingent user-base in the course of their new product development. A highly skilled workforce and good infrastructural provision are also two of the core elements of a Living Lab innovation process.

My analysis based on stakeholders reports, internal documents and primary data show that the core of the more innovative Space Sector activities in Scotland is clustered around three main subsectors in three different industry and geographical areas: component electronics and communications systems engineering in Dundee, manufacturing of nano-satellites in Glasgow and satellite data analytics and applications in Edinburgh. Each of these cities/clusters has also been linked to a research specialisation of the local University: the Dundee one is centred on data transfer and space communications electronics at the University of Dundee; the Glasgow (Strathclyde) one is centred on space hardware engineering and astrodynamics at Strathclyde University; and the Edinburgh one on applications of Earth Observation satellite data, in particular in the field of geosciences through the University of Edinburgh. Here we find another of the Living Lab core enabling factors – the research capabilities.

An Alternative Model of Vertical Value Chain Integration

The Agile Space Group was launched as part of Data. SPACE 2017 conference in February 2017 in Glasgow. The key partnership at the core of this group is the one between upstream nano/cube sat satellite platform developers, Clyde Space, and downstream data analytics company, Ecometrica. Though the two seldom collaborated on a specific project together in the past, they are the undoubted primes and critical thought leaders of in the upstream and downstream arena of thee R&D-active part of the Scottish Space Sector. Through this leadership, they have a significant influence on other players, especially their collaborators.

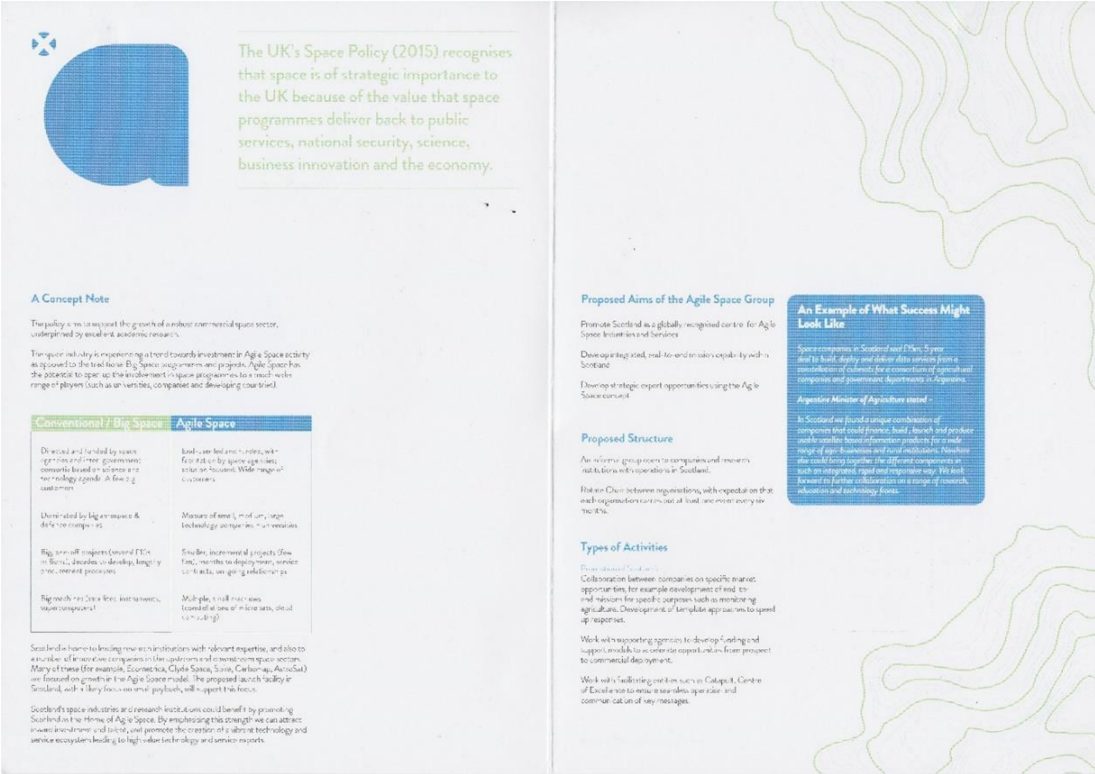


Figure 6 - Agile Space Group's promotional flyer outlining some of the key concepts behind its creation, in particular, its oppositional pitch with respect to the "Conventional / Big Space" and the noted loose organisational aims, structure and activities. (Scanned by the author.)

The express state purpose behind the establishment of this group (see the scanned leaflet on Figure 6) was the consolidations of dispersed players across Central Scotland, to care a globally unique offering of a dynamic, flexible, and loosely integrated nano-satellite data value chain, by which at some point in the future a potential customer could obtain all required technology and service capability at a single place (i.e. In Scotland) (also see schema in Figure 7). Due to specificities of the emerging New Space market, the Group explicitly aims at a non-institutionalised/formalised assemblage of players, by which complex and dynamic offerings are convened ad hoc, without much draw on resources or any physical infrastructure. As such, the groups' eventual operational structure is unclear and it is possible to foresee several potential configurations, such as trade/industry body, a permanent consortium, or even an incorporated subsidiary of multiple shareholders. A further objective for this group is to represent the stakeholders in the New Space Industry in the (Scottish) political arena and promote them internationally.

Other firms, for instance (Stevenson) Astrosat, based near Edinburgh and originally a downstream space data analytics firm, has begun processes of expanding activities along the value chain. In particular, they have engaged in the acquisition of satellite data receiving "ground stations" and commenced involvement in upstream hardware development. This approach can still be seen as somewhat complementary to the overall vertical value chain integration proposed by the "Agile Space" group, as it aligns with the core message/vision of "agility" in innovation and cross-sectoral collaboration in developing appropriate products/services and their support infrastructures. As such, the "Agile Space" paradigm can be framed more as an approach to innovation and business development, rather than any formal institutional grouping, a point further examined in the next section.

This critical mass of development in the (New) Space arena has also been touched upon in a regional development strategy: Aerospace, Defence, Marine and Security Industrial Strategy for Scotland 2016 led by the Aerospace, Defence, Marine and Security Industry Leadership Group (ADMS-ILG) at Scottish Enterprise, the regional economic development agency (Scottish Enterprise, 2016a). A more detailed and specific action plan is currently being developed to enact this strategy in practice in each of the subsectors, including a separate plan for Space Sector, and engage across the industry. Here too, the "Agile Space" seems to be used as a type of collective branding for the ecosystem's innovation offering, rather than any formal consortium.

Figure 7 - A conceptual representation of the completeness of the Scottish space sector SMEs "loosely-integrated" value chain, from components manufacturing and hardware integration (top left) through emerging launch capabilities (bottom left) and then data downlink (bottom right) and analytics applications (top right). Some degree of circularity is achieved as data demands are then leading the development of new hardware. (Collage created by the author.)

Hence, I propose that in the context of the transformative industry transition to New Space, the evidenced emerging and expanding Scottish New Space Sector and its consolidation around the somewhat elusive "Agile Space" concept, using the "Living Labs" framing of innovation is a promising avenue for understanding the emergence of this new innovation environment. Specifically noting the solid geographical, political and economic boundedness, the crucial links between firms and their environment, the interdisciplinary clusters around Scottish city-based universities and moves towards new types of value chain integration/stabilisation, I propose that a more systemic model of innovation is needed to frame these developments – a combined Agile Space Living Lab. In the next section, I develop further the analysis of these links using primary empirical data from my ethnographic study.

The Emergence of an Innovation Paradigm: "Agile Space Living Labs"

As referenced earlier, critical for the emergence of Living Labs innovation framework are R&D projects in information technologies, particularly as related to other modern societal challenges, such as combining resources-intensive urban living with concerns for environmental protection and the proposed solutions requiring the introduction of smart infrastructure (Voytenko *et al.*, 2016). The challenges associated with technology development in these "laboratories" are most often identified as big data (analytics) and the interconnectivity of human and non-human actors, often referred to as "internet of things", while the social challenges most often relate to information distribution and trustworthiness of such. Closer integration of users in the R&D processes supposedly on one hand enables a better understanding of the requirements on the production of information and dissemination of solutions, as well as on the other hand establishes a greater degree of trust in the validity of the design of such applications (Pierson and Lievens, 2005; Eriksson *et al.*, 2006).

Crucially, space-enabled technologies already play a significant role in this arena in particular by the use of spatial data and services in the development and operation of applications. In particular, this is to do with front-end use of Earth Observation (EO) data in analytics, the meta-level integration of satellite positioning data for geolocation of other data and information solutions via global positioning services (GPS), and the indirect back-end use of satellite-enabled telecommunications for distributed (cloud) hosting of applications. This multi-layered integration of space-related technologies is very common across a variety of modern IT applications and is particularly prevalent in social media/ networks and information services (such as internet browsing and navigation).

However, in the recent decade, a more direct application of Space Sector's solutions is also emerging, whereby the key data-source for an application is closely related to a specific set of space-derived/enabled data. An interesting example of such is a host of environmental monitoring solutions which relate to urban infrastructure and (agricultural) land use and management. For instance, heat detection from space is used as a rough indicator of energy efficiency, waste management can be tracked locally via GPS and analysed for carbon footprint, and satellite images used to monitoring irrigation of land can help maximise farming yields and spot structural problems leading to landslides and/or erosion. All of these are just some of the examples of applications pursued by SMEs in the downstream New Space Sector in Scotland.

Importantly, these applications clearly combine the scientific value of data from space-enabled technologies and user-driven demand for information solutions, whether on an individual or community level. Hence, this integration of techno-scientific and social spheres requires an inclusive approach to innovation which fits well under the Living Labs labelling. Though many Living Labs solutions rely solely on user-generated data and have little connection to Space Sector, in many cases those (meta-)relationships already exists and with the more flexible and user-tailored approach to the development of New Space industry more broadly, the relevance of the Living Labs model for Space Sector is increasing. As highlighted in the quote from one of the Scottish Agile Space SME's mentioned earlier, it is precisely this expansion of the innovation activity across a wider geographical area (city or region) and to non-sectoral stakeholders, which makes Scottish Space SMEs different from more "clustered" counterparts in campuses such as the Space Gateway at Harwell in Oxfordshire and hence perhaps better suited to exploit a Living Lab configuration through a wider network of stakeholders and users, a fertile social environment and sufficient infrastructure and natural diversity.

Key Features of Agile Space-Powered Living Laboratory

The combination of the emergent New Space industry and excellent conditions for forming Living Laboratories in Scotland led to a particularly fruitful environment to research these new/emerging trends. I have completed a firm-level analysis of the innovation processes deployed in a selection of typical cases (Yin, 2009) (downstream firms in "New Space", "Transitional", "Classical" Scottish Space Sector segment), as well as the evolving organisational and operational structures within the firms. Specifically, qualitative examination of the new product development (NPD) (Carlile, 2002; Neapole, 2005; Pullen *et al.*, 2012; Vidmar, 2015) projects and social network analysis (SNA) (Scott, 1988; Giuliani, 2007a) of the innovation networks of leading downstream SMEs in Scotland was performed in order to understand the key notable trends in the development of the Agile Space Living Lab innovation model. This is supplemented with a more detailed product-level case study to illuminate further the development of interactions and gradual changes in emphasis on various possible alignments of the available technological solutions, or pathways for their development, and the “outside” “real world” interest in addressing particular societal challenges.

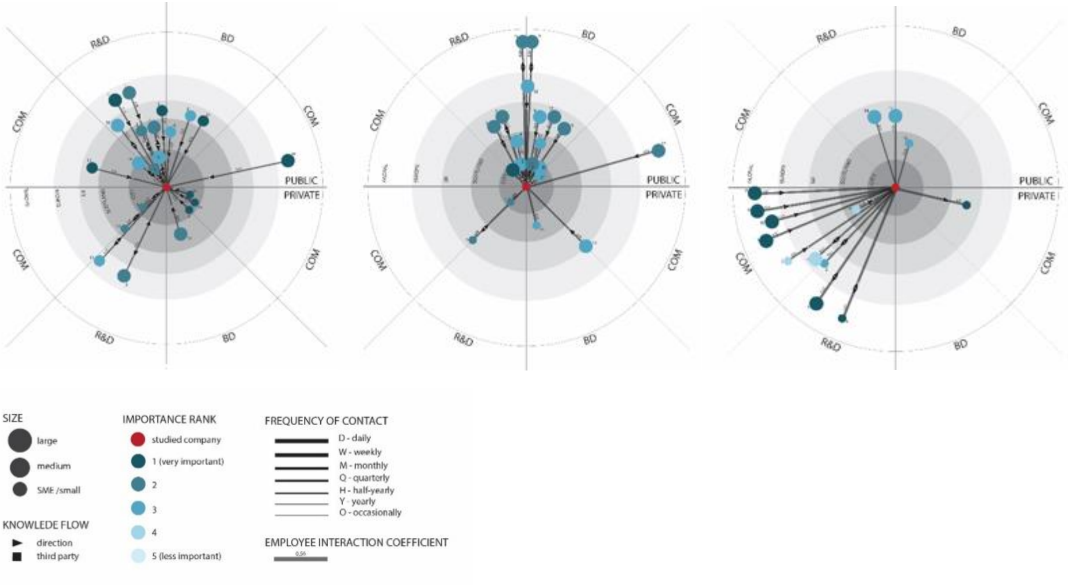


Figure 8 - Innovation networks of three Scottish downstream SMEs. The most recent “New Space” firm at the left has the densest, yet the most local network of partners, whilst the right one, established firm, is the most globally oriented. A similar trend is also noted in character of the firms’ partners, where the public sector (academia, intermediaries, development agencies, government) are more heavily present in the left “New Space” SMEs’ network, whilst the right one has the fewest of public partners.

From such analysis, I have identified several significant trends. For instance, the innovation networks within the New Space downstream segment of the Scottish Space Sector – i.e. Agile Space -, show that these emerging enterprises link with a greater number of actors in their NPD processes in contrast to their more “traditional” predecessors (as seen in Figure 8). They also engage more with public sector partners, in particular, academia, inter-organisational brokers and intermediaries, and (public) lead users, who are often (local or national) government or citizen groups. Furthermore, the geographical distribution of these partners indicates that the Agile Space firms have a far greater density of local partners in comparison to global ones, contrary to the previous generations of Scottish downstream space SMEs.

Expanding networks also lead to a more “open” mode of new product development (NPD), due to an increasing necessity to accommodate dispersed expertise and interdisciplinarity, leading to a breakdown of the traditional hierarchical structures within the firm, yet an increasing need for formalised and standardised project management, in order to harness all available internal and external capacity. This is evidenced in qualitative data I have collected, as the “New Space” firms adopted a structured project management approach to new product development including stages such as “defining user and technological requirements", "prototyping", "productising" and "beta-testing", and progressing through formal stages of development such as the technology readiness levels (TRLs), involving research partners, lead users and other stakeholders (funders, regulators, etc.) at different points along the way. This is in contrast to the older, more established and less "agile" firms, who develop new products in more top-down manner with the management team and new recruitment the key drivers for embarking on new innovation projects, which are often conceived on the "back of a napkin" and only tested with users once the "design" is nearly complete.

Overall, these changes noticed across the Scottish downstream SMEs are underlining a transition between two different approaches to innovation – from a "closed" hierarchical model with smaller and more global innovation network, to a more intense "open" innovation model linking to a variety of public sphere partners and deploying a much more interdisciplinary and inclusive new product development processes. These changes critically impact the way exploratory work is done within firms and is of particular significance for the firms' ability to build "agility" in the face of changing opportunities and difficult markets. Hence, in the next section, I turn to an example of the importance of deploying an Agile Space Living Laboratory in practice in a downstream New Space NPD project in Scotland.

Case Study: Living Laboratory Experimentation Enabling Business Development

Since the expansion of the Earth Observation programmes, and in particular in the recent era of open access to space data, applications developers have predominantly targeted climate (change) as a key target market (Nath *et al.*, 2016). However, due to political contestation and limited commercial value of Earth monitoring, the attention of most developers, in particular in countries with newly emerging space sectors like Scotland, has shifted towards more developed markets, such as agro-food and forestry. One case of deploying a living-laboratory-enabled "transitional" project is outlined in Box 1, below.

Wall to Wall Soil Alerts for the UK

This project was developed by Ecometrica, an Edinburgh based geospatial intelligence and mapping applications SME, whose platform is marketed as allowing businesses, governments and organisations to make smarter decisions and build long-term value. Their initial products related to large-scale environmental mapping and monitoring, in particular, to tackle carbon management and related challenges posed by climate change. However, as the company was interested to explore other, more mature markets, too, specifically, agro-food and forestry.

Hence, the aim of the specific project analysed here was to investigate the feasibility of acquiring timely and accurate soil moisture content (SMC) data for the UK from Synthetic Aperture Radar (SAR) remote sensing, specifically from the new European Space Agency's Sentinel-1 SAR sensors, the data from which is available for free. The work assessed soil moisture at field sites across the UK using SAR data returns and compared it to ground measurements to see if it was feasible to use SAR remote sensing for establishing a wall to wall alerts for soil moisture extremes.

The project was looking at the development of a new service for the public sector. The estimated potential market value of such service is in the region of £1.2 to £1.5 million. It could also deliver significant societal and economic impact as significant benefits are seen to be in the following applications:

- Flood prediction
- Diffuse pollution
- Agriculture advice: identifying priority areas for renewal of field drains and trafficability information
- Nitrogen Vulnerable Zones (NVZs) and slurry management
- Peatland management, fire prevention and wetting
- Improved greenhouse gas estimation for soils.

This could bring about potential annual savings to public sector services and their stakeholders in the region of £11 to £35 million. This was also noted as a key concern with the main funders of this feasibility study project, the UK Government's Space for Smarter Government Programme, as flooding was seen at the time (2015) as a big societal issue and an acute problem. In addition, European Space Agency (ESA), UK Space Agency and the Satellite Applications Catapult were eager to invest in R&D to exploit newly released (publicly funded) space data from the Sentinel satellites.

In fact, for Ecometrica, this is one in a series of projects which aim at exploring the public sector markets, as their current main customers are private firms. Though technological barriers prevented this project from becoming a full commercial service, it is believed that future work with improved technology (available in the near future) and more comprehensive data could see this as a major business opportunity. Most importantly, through establishing a consortium of partners who worked on this project, and which include potential lead users (and customers), the company began the process of positioning itself within the market to exploit further opportunities. This included several national institutes, crucially Scotland-based James Hutton Institute and Scottish Rural University College.

Box 1 - An example of an agro-tech project from a leading Scottish space data applications developer.

This is not an isolated case, with the majority of downstream SMEs in Scotland (5 out of 7) developing at least some of their products in either agro-food or forestry domains. These solutions, however, can only be effectively launched into highly competitive markets, if they have established credentials for reliability and robustness. The process of the on-the-ground validation or “ground-truthing” (Pickles, 1995; Robbins, 2003) is particularly important, as well as is user-friendliness of the final application. These are established by integration of lead users into the NPD projects through expanding innovation networks, in order to use both on-the-ground data as well as evaluate the usability of test solutions within the partner’s work processes.

For such, the Living Lab framework provides an excellent model, whereby the physical and social infrastructure enables a continuously evolving (re)configuration of research organisations, enterprises and concerned stakeholders (various user and public groups). These actors can exchange not only ideas for new product development and later incremental improvements, but critically shape the demand/market for new technological solutions, as well as define their value, both in general/concept as well as specific/product terms. For instance, looking at the project presented in Box 1, the SME involved was creative in applying for a funding programme with a feasibility study for a product, which was addressing an acute need in the target market at the time (public sector) and was tapping into a specific interest by the same stakeholders (i.e. government). They attracted several key partners and users to the project and are in the process of establishing a “consortium” of SMEs and research organisations with related complementary products.

In particular, the partnerships established here are seen as the key “breakthrough” to access the target market as well as means to reach end users (i.e. farmers). The company considers that further buy-in is needed by these stakeholders before roll-out (including product validation, which is currently in progress). Though the product at the centre of this study has not yet reached the market, the company benefited from further investment (including a government grant of over £150k) and experienced a reasonable amount of growth on the back of it. It is particularly interesting that this project, and many others across the industry, are also acting as catalysts for firms' transitions into new markets. Specifically, many firms are moving away from public sector dominated environmental monitoring and towards commercially larger agro-food and forestry sectors. Such moves are in part from necessity, as public funding for Earth Observation and Remote Sensing solutions is limited, as well as through discovery of opportunities of by engaging with lead users and entering into markets previously exclusively dominated by big business, which also sometimes stall technological development through institutional and systemic entrenchment.

Of further interest is the emergent prioritisation of solving (global) societal challenges of sustainability of agricultural production, though shying away from a potentially bigger emerging crisis of ecological disruption due to climate change. Partially, this could be explained through the political and economic context of these challenges, though one can pose an additional observation related to innovation as a phenomenon. As noted on the network diagrams in Figure 8, it is the emerging (New) Space firm who has the densest, yet also the most localised network of external partners, which is a notable feature of a Living Lab configuration. However, the prevalence of local partners also shifts interest to local issues and challenges, and whilst improving (smarter) agriculture is a direct interest to many if not most or even all locales, the acute societal challenge of global warming is seen as a global problem, with still relatively insignificant local impact in most places.

Conclusions and Further Research Agenda for Agile Space Living Labs

To conclude, the emergence of Agile Space Living Lab innovation practice marks an interesting evolution of the common wisdom about innovation in high-tech industries, which has already been similarly challenged by the ICT and biotech sectors. However, comparatively more complex systemic nature of the innovation in the Space Sector makes Agile Space example crucial for gaining an understanding of this paradigm shift in the practice of innovation, which is particularly important for deepening the understanding of the emergence and consolidation of new geographically-bound sectoral innovation systems (GSSI), which are also sometimes referred in policy arena as smart specialisation (McCann and Ortega-Argilés, 2015). Here, the emergence and development of Agile Space and its relationship with the Living Labs concept provide a critical advancement of the core understanding of high-tech innovation and regional proliferation.

In particular, as outlined in the analysis of the trends and empirical data presented above, I have identified three notable trends:

- Firstly, there is an increasing role for localised public stakeholders and focus towards the public good, with the critical advantage of the interconnectedness of physical, digital and social infrastructure, in the Agile Space-type innovation paradigm. However, this requires a different approach to managing the innovation process - how does this look like in the practice of innovation (i.e. new product development) and what are its key characteristics? What are key similarities and differences with the traditional Space Industry (2.0)?
- Secondly, a new type of loose value chain integration is emerging from the Agile Space conceptualisation of the (New) Space Sector in Scotland. This is related to the structure of the Open Innovation and Living Labs-type of the innovation process, and the geographical dispersion and clustering of the different segments of the R&D activity. However, how does this loose integration of the value chain comes about, how is it structured and how does it operate?
- Thirdly, high-tech innovation activity is emerging in a new geographical domain, i.e. (New) Space Sector thriving in a previously peripheral country like Scotland. The application of a Living Labs-type of (open) innovation model, coupled with a loose value chain integration within the emerging (New) Space Sector, created a distinct competitive advantage of a type of Smart Specialisation in the form of Agile Space. Hence, a central new question emerged as to what is/are the role(s) of public stakeholders' (local, regional, national, international) in the support of the deployment of this innovation model and its focusing on a specific sector?

Based on these conclusions, a new set of key questions regarding the frim and network level mechanics of these innovation processes arose. In order to expand on these findings further, I propose the following three strands of future research:

Analysing Practice: Co-construction of Technology and Social Learning

The above innovation environment or system is built on the principles of co-development of technology, with a critical need for understanding the relationships between the various actors and artefacts involved (Pollock and Williams, 2008). As such, a deeper social-scientific understanding of innovation processes described above is needed, in order to conceptualise how Living Labs operate in relation to firms. In particular, as exposed in the various theories and conceptualisations of social learning in socio-technological systems, a major challenge is the alignment of interests and development of functional and meaningful intra-organisational interaction. In particular, a research framework has emerged: Biographies of Artefacts and Practices (BoAP), which is proposing to acquire such deep understanding of social learning in innovation processes by engaging in strategic multi-sited ethnography (Pollock and Williams, 2010; Williams and Pollock, 2012). Future work in this area should examine the organisational structuring and interactions with external partners in the innovation process, and specifically analyse its (inter)dependence on external knowledge acquisition. This has been conceptualised through the Open Innovation paradigm (Chesbrough, 2006; van de Vrande *et al.*, 2009; Lee *et al.*, 2010) as a critical ingredient of contemporary new product development in SMEs, yet how this important dimension links to the Living Labs conceptualisation has not been fully explored so far. Furthermore, such micro-level analysis within SMEs should then lead to examining the meso-level development of intra-organisational networks and structures, to understand the collective emergence of the Agile Space paradigm.

Analysing Structural Linkages: Social Network Analysis of the Emergence of New Space in Scotland

Intra-organisational linkages and open innovation networks have been shown to be of central importance for the regional Living Lab conceptualisation (Leminen, Westerlund and Nyström, 2012), which can also be observed here in the analysis of Agile Space. In particular, the systemic nature of the (larger) Living Labs and the loose value chain consolidation proposed through Agile Space make it pertinent that those links and their structural assemblage in a regionally-bound sectoral innovation (eco)system are examined. Hence, additional research is required in the emergence, development and the current structure of these links and networks. In keeping with the above BoAP methodological agenda, I propose a bottom-up ego-centric social network analysis (Ego-SNA) as an optimal approach to such further work. A central interest beyond the structural and evolutionary concerns is also the role and degree of involvement and centrality of non-business and R&D actors, i.e. the innovation intermediaries. This ties in closely with developing and enacting (public) policy for technological advancement and economic development. This is further related to innovation development concepts such as absorptive capacity (Zahra and George, 2002; Todorova and Durisin, 2007; Lazaric, Longhi and Thomas, 2008; Foss, Lyles and Volberda, 2009; Marabelli and Newell, 2014), which is the ability of an (eco)system to “absorb” and mobilise knowledge (and other related resources) to produce new products.

Analysing Policy: Innovation Intermediaries and Interventions

Further research is also needed to characterise better the policy options available to stimulate the growth of innovation activities in (eco)systems through SMEs operating in the high-tech arena(s). Here, lessons can be learned to expand the Space Sector in my case study, Scotland, as well as in other similar regions and areas. Furthermore, more board lessons can be learned applicable in many other high-tech contexts. Of particular concern is the current lack of clarity as to the various roles and actions performed by the innovation intermediaries (Venturini and Verbano, 2014) and the contextualised sectoral needs (Duff, 1996; Martin and Scott, 2000). Hence, in order for Agile Space Living Lab innovation model to be understood and developed further, analysis of the roles and activities of innovation intermediaries is needed. In particular, a more typological model of available interventions, which can be deployed to assist in the development of geographically-bound sectoral systems of innovation would be welcomed by practitioners (policymakers and innovators/entrepreneurs) as well as analysts.

Chapter 3: New Space and Agile Innovation - Understanding Transition to Open Innovation by Examining Innovation Networks and Moments

Introduction

The Space Sector is currently undergoing a major industry transition from Space 2.0 to Space 3.0, i.e. into “New Space” (Adlen, 2011). Overall, this is billed as a transitioning away from states and multinational corporations driven markets towards more democratised and de-centralised economic activity based on academic research and small-to-medium-size enterprises (SME) (Adlen, 2011; Willetts, 2013; Vidmar, 2019b). The efficiencies and added value enabling such a shift is built upon significant changes of, on one hand, decrease in cost of developing space technology, and on the other hand, increase in openness and accessibility of space data. Specifically, these changes are enabled by cheaper core technologies (electronics, additive manufacturing / 3D printing), increasing quantity of, and access to, open source data (from public programmes, such as ESA/EU’s Copernicus) and new system/operation solutions (e.g. cloud-based platforms for operation and data management, standard components and “flat pack” hardware) (Adlen, 2011; Vidmar, 2019b).

These recent developments enabled new entrants to emerge from traditionally peripheral geographies and though as before the markets are built around three main areas of applications: Earth Observation (EO), (satellite) navigation and telecommunications/broadcasting (London Economics, 2009), the New Space players demonstrate a significant amount of growth and have led to the increase in economic and political value and importance of the Space Sector. In this respect, Scotland in the UK is a particularly good example, having formed a very significant subset of the UK’s (New) Space Sector (London Economics, 2019) and contending to be second to Silicon Valley in the USA (Macdonald, 2017). With three clusters of activity in Glasgow (hardware), Dundee (communication and electronics) and Edinburgh (data analytics), it contains a spread of SMEs over the entire value chain. Furthermore, there is an ambition for the UK to take 10% of the global space industry by 2030 and Scotland to again take 10% of that (Space IGS, 2014), i.e. 1% of global total.

Despite these significant changes and the economic and political interest these development have generated, their features and implications are poorly understood, as previously outlined by Vidmar (Vidmar, 2019b, 2020). There is particularly the need to understand the "organisational structuring and interactions with external partners in the innovation process, and specifically analyse its (inter)dependence on external knowledge acquisition" and "the emergence, development and the current structure of [innovation] links and networks" (Vidmar, 2019b). These issues are critical to address, both to understand the current trends in the Space Industry, and in particular the implications arising for policy and on-the-ground operations, as well as the wider transformation of previously closed high-tech innovation systems in the transition towards Open Innovation (Pullen *et al.*, 2012; Chesbrough and Bogers, 2014; Kerry and Danson, 2016; Vidmar, 2019a) as found in a specified locale. Hence, this paper is outlining an in-depth study of the geographically-bound sectoral system of innovation, that of the (New) Space Industry in Scotland, which is now transitioning from an emergent locale to a world-leading powerhouse (Vass, 2013; London Economics, 2015a; Scottish Enterprise, 2016a; Macdonald, 2017).

Our work is based on a two-fold inquiry into the innovation networks and the structure of SME's new product development (NPD) processes (Green *et al.*, 1999; Giuliani and Bell, 2005; Lee *et al.*, 2010) to show 1) the link between Open Innovation dynamics across intra-organisational connections (Simard and West, 2006; Vanhaverbeke and Cloodt, 2006; Lee *et al.*, 2010) and 2) the micro-level SMEs' organizational behaviour in the absorption of external knowledge, something often referred to as "absorptive capacity" (Zahra and George, 2002; Huang and Rice, 2009; Sun and Anderson, 2010). In particular, we are interested in (how) has the structure of innovation networks changed in the transition to more Open Innovation as adopted by the New Space SMEs? And (how) has this transition affected the structure of NPD processes, which are at the core of knowledge absorption into an SME? Furthermore, how can the link between the two levels be best conceptualised?

To answer these questions, we propose a new conceptual tool based on the notion of "innovation moment" (Edwards, 2000; Edwards, Delbridge and Munday, 2005) to describe the connection between the various literatures and studies accorss these two different levels. In particular, as this study aims to understand the structure of innovation networks

(Freeman, 1991) and NPD management (Harmancioglu *et al.*, 2007) strategies across different firms, we also focus on examining their propagation within geographical and sectoral configuration. To achieve this, we define a critical innovation systems framing and develop a new a mixed-method research design.

In the following section, we begin by reviewing the two bodies of literature underpinning this research, namely the Open Innovation and Structural Absorptive Capacity takes on knowledge flows. In particular, we expose the need for understanding the mechanics of links between meso-level innovation networks and micro-level SMEs' NPD processes. In the subsequent methodological sections, we outline how such research can be conducted within a geographically-bound sectoral system of innovation (GSSI), while explaining the deployed methodology, a mixed methods approach combining quantitative ego-centric social network analysis (SNA) and qualitative "innovation moments" study. Finally, we report the results of empirical work within the selected case study, the Scottish Space Sector, and present an analysis of the key correlation between specific features of processual absorptive capacity, the "openness of innovation" and the shape, size and positioning of SMEs' within innovation networks. We touch on key conclusions, limitations and avenues for further work at the end.

Open Innovation and Structural Absorptive Capacity

Open Innovation in SMEs and Innovation Networks

Small-to-Medium-size Enterprises (SMEs) are facing a very challenging environment in the fast-paced knowledge economy. In particular, increasing knowledge complexity and its wide(er) distribution makes it far more difficult for an SME to innovate by themselves. SMEs address the challenges of the shortage of time, resources and expertise by finding new ways to connect to other (external) actors in order to (out- or in-) source knowledge and generate value out of it. Hence, there is a growing need to create new frameworks and systems to "connect these seemingly disparate activities together" (Chesbrough, 2011) and to make it easier for SME to link-up to other sources of knowledge and expertise. The knowledge flows which are crossing the firm's boundaries are associated with "open innovation", a paradigm shift explaining the supra-organisational nature of innovation in some of the most fast-growing economic sectors in the late 20th and early 21st century (Chesbrough, 2003, 2011; Faems, 2008; Chesbrough and Bogers, 2014). To summarise this, a company that generates all of its innovation internally is considered as adopting a "closed" innovation model, where control over NPD processes and full internal commercialisation of IP is deemed crucial. In contrast, the “open” innovation model is centred on a dynamic interaction crossing the firm boundaries, with some ideas/knowledge being sourced into the NPD process from outside the company, as well as some internal ideas being licensed out from company’s NPD process to others for commercialisation (Chesbrough, 2003).

The mechanisms of open innovation in SMEs are charted by Lee et al. (Lee *et al.*, 2010) and involve potential insourcing of knowledge and resources (investment), outsourcing of intellectual property (IP), and establishing new business models or entering new markets. Hence, these kinds of interactions with external partners are crucial for understanding the NPD process in SMEs. However, the open innovation dynamic in SMEs is not fully understood, nor is there much analysis as to how the macro systemic level and the micro (open) innovation level are interconnected. In particular, as most processes of open innovation are based on interaction with external partners - and especially knowledge dissipation is done through communication and sharing between individuals and organisations (Brown and Duguid, 2001; Malerba *et al.*, 2016) -, a key part of any innovation process is its interconnectedness with “other” actors, processes and systems (Simard and West, 2006) through (meso-level) “innovation networks”.

Furthermore, several studies have shown that firms’ innovation networks can be related to their performance (Gertler and Levitte, 2005; Zaheer and Bell, 2005; Fleming, King and Juda, 2007; Colombo *et al.*, 2011), even though further qualitative examination of how and what knowledge is the subject of intra-organisational ties has been called for (Zaheer and Bell, 2005; Simard and West, 2006). Specifically, firms in central positions and with internal capabilities are proposed to be benefiting most from an open innovation mode of NPD development (Zaheer and Bell, 2005), regardless of whether they are located in closely-knit “small world” networks or bigger structures (Fleming, King and Juda, 2007). Hence, we hypothesise that the firm’s innovation network structure is related to its degree of openness of innovation process and significant differences should be found when comparing firms adopting the Open Innovation model with respect to those who not. The understanding of these differences can also expose the importance of various (types of) partners in this transition.

The ability to link these meso-level structures with SMEs’ internal capabilities to make use of the networked interaction within NPD is specifically related to the concept of “absorptive capacity", i.e. the ability to "recognize the value of new information, assimilate it, and apply it to commercial ends" (Cohen and Levinthal, 1990).

Structural Absorptive Capacity and Organisational Learning[15]

Absorptive capacity has been identified by past studies as the crucial approach in conceptualising the understanding of cross-organisational knowledge flows (Foss, Lyles and Volberda, 2009; West and Bogers, 2014). However, Marabelli and Newell (Marabelli and Newell, 2014) found that most organisation studies on absorptive capacity focused on prior knowledge already owned by a firm, and assumed that new knowledge can be easily shared and used, based on the "epistemology of possession" (Cook and Brown, 1999). While this approach is valid, it does not allow for direct observation of the complex processes through which absorptive capacity is mobilised by a firm. In particular, having prior knowledge and open communication channels, even when acknowledging the iterative nature of what happens through these channels, does not fully explain how knowledge is "absorbed" into an organisation and is then used in innovation processes. Instead, the full understanding of how absorptive capacity comes into being has to entail what occurs in practice as firms translate knowledge "into the scene" (Nicolini, 2011).

Hence, we propose to adopt a processual view of absorptive capacity (Zahra and George, 2002; Todorova and Durisin, 2007; Foss, Lyles and Volberda, 2009), which leads us to a focus on practices to recognise, assimilate, transform and exploit external knowledge (Sun and Anderson, 2010; Marabelli and Newell, 2014). Processes of organisational learning, as both the embodiment and precursors to establishing the absorptive capacity, are of particular interest (Crossan, Lane and White, 1999; Spithoven, Clarysse and Knockaert, 2010; Sun and Anderson, 2010; Lewin, Massini and Peeters, 2011). Noting that both intra-organisational learning though innovation networks, as well as knowledge management within these connections, are dependent on organisational practices and routines (Powell, Koput and Smith-Doerr, 1996), leads us to framing absorptive capacity as a structural feature of organisational behaviour. In specific terms, the study of organisational learning and absorptive capacity has been recognised to work best when focusing on new product development (NPD) processes (Sun and Anderson, 2010). We specifically propose that

---

[15] This perspective on absorptive capacity was formulated jointly with my supervisor, Alessandro Rosiello, and colleagues at Warwick and SPRU, in particular Dagmara Weckowska.

understanding the formalisation and standardisation of NPD processes within firms, as well as their management, are a precursor to understanding the structural absorptive capacity. Furthermore, based on past research identifying that organisational learning occurs along geographically and cognitively proximate domains (Boschma and Frenken, 2011; Cooke, 2012), we hope to provide specific evidence for such trajectories which can serve as future heuristic devices.

However, these processes are difficult to document directly, as they are relatively abstract in nature. Hence, a more direct epistemological approach is to focus on the new product development processes as the manifestation of organizational practices and behaviors within a real-project context. Consequently, in order to study the changing structure of absorptive capacity, we derived it into a new conceptual framing for studying the structure of NPD – i.e. the “innovation moments” presented in the next section.

“Innovation Moment” as a Conceptual Tool to Understand NPD Process’ Structure

Traditionally, the processes of innovation were framed in either linear or cyclical fashion, though neither framing alone was accepted as a sufficiently full account (Pavitt, 2006). Instead of such simplistic models, descriptive empirical research has identified that “fuzzy/messy” and complex dynamical processes govern NPD processes in SMEs (Swann, 2009). Consequently, we are adopting a phased/modular approach, with overlapping stages/work processes, which combines schematic clarity with capturing (some of) the fuzziness/messiness. Hence, there is a need to built a representation of the routines and processes of structural absorptive capacity, which can bridge the different understandings of innovation processes on meso-/systemic and micro-/NPD level of organisational behaviour. This will assist us in understating the (changing) structure of NPD processes undergoing a transition towards Open Innovation.

The proposed unit of analysis in a studied SME is an “innovation project”, i.e. a development of a (single) product, following the CEN/TS standard for innovation management (CEN, 2013). This analytical approach is based on a distinction between “specific innovation projects” and “general innovation management”, similarly to the Oslo Manual (OECD, 2007a), separating “object” and “subject” approaches. The object approach is based on a single business innovation project, e.g. the development of a new product, and the subject approach, which looks at a firm in its entirety. As such, an ”innovation project‶ can be considered a key unit of analysis of innovation in SMEs, which can help us analyse the organisational behaviour by which processes of innovation are managed in a firm, i.e. NPD's structural set-up, management interventions, etc. Even though there is an assumption that the overall structure of such a project can be synthesised in a generalist way, our research is open-ended and will establish such structure on a "project-by-project" and "firm-by-firm" basis.

Specifically, we propose to deploy the concept of "innovation moments", which was defined previously by Edwards and others (Edwards, 2000; Edwards, Delbridge and Munday, 2005) as a way to analytically explore procedural phases of NPD, or technical (R&D) or commercial (BD) challenges for the progression of an R&D project. This advanced conceptualisation of an "innovation moment" was derived from a combination of insights from innovation process (Edwards, Delbridge and Munday, 2005), organisational learning (Crossan, Lane and White, 1999) and absorptive capacity (Zahra and George, 2002). For instance, bridging the gap between the systemic understanding of knowledge flow and its specific local manifestation, we focused on the Sun and Andersons' (Sun and Anderson, 2010) proposed combining of lead organisational learning theories with the absorptive capacity framework. Specifically, Sun and Anderson align the processes of intuiting, interpreting, integrating and institutionalising knowledge from Crossan et al.'s (Crossan, Lane and White, 1999) theory of organisational learning with Zahra and George's (Zahra and George, 2002) framing of the processual view of absorptive capacity through acquisition, assimilation, transformation, and exploitation of knowledge. Based on these insights, we developed elements making-up our conceptualisation of the "innovation moment", by interpreting these four concept in the context of leading NPD stages.

In particular, though precise wording and models vary, most NPD analysis breaks down into several stages or phases, often referred back to the influential models such as the Stage-Gate (Cooper, 1990) and Booz, Allen and Hamilton (*New Products Management for the 1980s*, 1982). For instance, the later model lists seven stages: new product strategy, idea generation, screening, business analysis, development, testing and commercialization (Griffin, 1997; Bhuiyan, 2011). The first few phases, excluding business analysis but including development and testing, are also referred to as the "fuzzy front end" of the NPD process (Koen *et al.*, 2001), whereby the more "creative" and "knowledge intensive" part of the process takes place. Examining this structural view of NPD in more detail, we note that the fuzzy-front-end phases correspond well with the structural absorptive capacity framework. In particular, as seen in Table 3, these are quite complementary and led to the derivation of our own formulation of the innovation moment' definitions as a four elements structure containing problem/idea definition and analysis, expertise gathering, forming solutions and integration.

NPD Process Model Phases (Bhuiyan, 2011)	**Fuzzy Front End of Innovation** (Koen *et al.*, 2001)	**Absorptive Capacity / Organisational Learning Framework** (Sun and Anderson, 2010)	**Proposed innovation moment elements' definitions**
"**New Product Strategy**: Links the NPD process to company objectives and provides focus for idea/concept generation and guidelines for establishing screening criteria."	Opportunity Identification Opportunity Analysis	Acquisition / Intuiting	**defining** the problem/challenge,
"**Idea generation**: Searches for product ideas that meet company objectives."	Idea Genesis	Assimilation / Interpreting	**gathering** the required expertise and knowledge
"**Screening**: Comprises of an initial analysis to determine which ideas are pertinent and merit more detailed study."	Idea Selection	Transformation / Integrating	**forming** solutions through knowledge reduction
"**Development**: Turns an idea on paper into a product that is demonstrable and producible."	Concept and Technology Development	Integration / Institutionalising	**integrating** the acquired information into the product

Table 3 - Innovation moments elements' derivation combining NPD process and absorptive capacity / organisational learning insights.

Figure 9 shows that in addition to the conceptual framing outlined above, the derived "innovation moment" structure also contains an implied cycle of product development activity integrating the "problem-solving" aims of NPD (Thomke and Fujimoto, 2000). In particular, our conceptualisation aligns with the four-stage NPD experimentation cycle proposed by Thomke comprising of designing the experiment, building its apparatus, running the experiment and analysing its results for use (Thomke, 1998). The "innovation moment" structure also incorporates the cyclic nature of the processes of knowledge management, in particular by focusing on localising, obtaining, evaluating and utilising knowledge (Shin, Holden and Schmidt, 2001).

In addition, most analysis point out that the innovation process phases more broadly are not a linear sequence either, but occur simultaneously, with different aspects brought into the focus of the process at different, of then multiple, times (Pavitt, 2006). Similar stages and cycles of knowledge management within innovation/NPD process were previously also identified empirically in a variety of literature, in particular Open-Innovation-driven Living Labs (Almirall, Lee and Wareham, 2012), however, without formalising a conceptual tool such as "innovation moments", or contextualising it within a knowledge management, organisational learning or absorptive capacity frameworks. Hence, in order to explore the proposed conceptualisation empirically, both on firm-by-firm as well as on more systemic levels, a vital novel methodology needed to be developed, as is outlined in the next section.

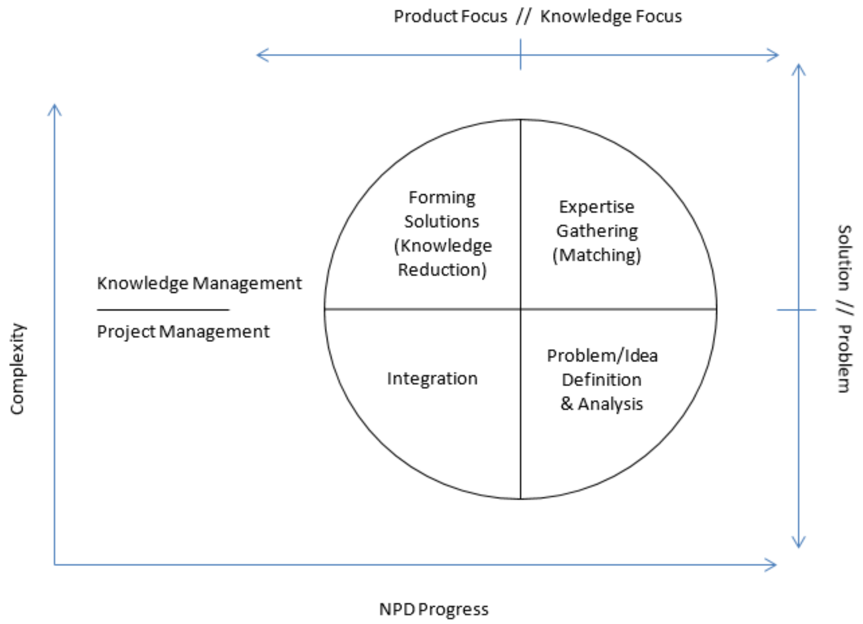


Figure 9 - A schematic diagram of an "innovation moment" – a new analytical tool for NPD process research.

A Multimethod Study of Innovation

Although we already argued that link(s) between the innovation networks and the localized innovation processes in NPD are key, very few studies merge research of networks with the details of the interaction. in particular, more work is needed to understand the nature and propagation of knowledge, the activities related to the integration of network sources knowledge in developed products and the mutual co-shaping of product development/innovation processes and the innovation networks (Lewin, Massini and Peeters, 2011).

The key principle of our analysis is that innovation is a process centred around people in organisations, their behaviour and decisions (Edwards, Delbridge and Munday, 2005). Thus, the key processual stages and development challenges at which the contested reality comes into foreground are the decision points at which the innovators have to decide the future of a project in face of a challenge to bring it to the market, i.e. what Swann calls development work (Swann, 2009). The identification of these key points within NPD and the way in which the environment – in particular interactions with external and internal sources of knowledge, technology and skills - is affecting those decisions, is vital for the understanding of the overall process, and this is the chief purpose of this empirical analysis.

Methodologies for dealing with the study of the contextual environment of innovation process, embedded in systemic elements, i.e. macro-level landscape, are well developed (and contested) within the innovation literature (Green *et al.*, 1999). However, linking those top-level approaches to specific instances of innovation in actual product development is methodologically underdeveloped. In particular, studying innovation in SMEs is challenging due to several factors, such as short timeframe, unclear boundaries, the informality of operations and access difficulties. Consequently, a suitable geographical-sectoral innovation system framing is required, as presented in the next section. In addition, we developed a mixed-methods framework, inspired by the "strategic ethnography" principles within biographical approach to innovation studies (Pollock and Williams, 2010), with a core two-fold inquiry. The evolving innovation network and its interconnectedness to specific NPD processes can be examined best through a mix of quantitative Ego-SNA techniques, while firms' practices are best studied qualitatively using a "sensitising concept".

Defining Geographically Bound Sectoral Systems of Innovation

Overall, the empirical insights from a mixed ego-SNA and qualitative semi-structured interviews will be used to advance theorising on the nexus between systemic innovation networks and firm-level NPD practices, following the case study-based theory building approach (Eisenhardt, 1989). In comparison to most other proposals (Bergek *et al.*, 2008), our methodology defines a much broader framework of inquiry of how innovation network(s) operate and what effects they have on specific innovation processes. However, in order to analyse this nexus in sufficient detail, it is important to pick an appropriate case study (Yin, 2009). In particular, we chose the Scottish Space Sector for our subject of study, as it is important for it to be of a size allowing for in-depth study, whilst also being comprehensive and complete, i.e. actors along the whole value chain and at all stages of development. Furthermore, in order to satisfy our theoretical interests, the studied case should be a clearly defined sector, and specifically for this research, being high-tech, fast growing and transitioning from closed innovation models and high-level corporate stakeholders to a dynamic open innovation arena and a consumer-driven market.

In order to conceptualise such a setting, geographically-bound sectoral system of innovation (GSSI) framing was developed. In order to homogenise the knowledge and technologies (sector) and institutional (geography) framing – as well as expose "actors and networks" as one the critical subject of research (Malerba, 2005). Such an approach is also in direct alignment to the analysis of the need within Open Innovation paradigm to jointly study NPD-network innovation dynamics across the SMEs boundaries, as outlined earlier.

GSSI has been fundamentally based on a very successful framework for the study of intra-organisational phenomena of innovation, namely the Innovation Systems (IS) (Edquist, 2001). It has been shown that the innovation systems model can be framed using geographical boundaries such as national (Freeman, 1991; Lundvall *et al.*, 1992, 2002; Nelson, 1993) or regional (Cooke, Gomez Uranga and Etxebarria, 1997; Cooke, 2001; Asheim, Smith and Oughton, 2011) units, or by separation of economic activities to (different) technological (Hekkert *et al.*, 2007; Bergek *et al.*, 2008) or sectoral (Malerba, 2002, 2004a, 2007) platforms. These different levels of inquiry however by and large share the same common framework of the Innovation Systems tailored for scope and aims of different researchers' interest (Frenz and Oughton, 2005). For instance, as noted by Edquist, system boundaries can be drawn in three different ways: geographically; sectorally; and in terms of system activities or functions (Edquist, 2004; Asheim, Smith and Oughton, 2011).

Hence, in our defining of boundaries of the studied system we rely on the proposition that any entity deemed to be part of such a system has to be within the geographical boundaries of the studied locale (region) as well as part of a value chain of a specific innovative endeavour (Hansen and Birkinshaw, 2006; Roper, Du and Love, 2008), which is recognised as a constituent of the studied sector. Similar to Malerba's definition of a "sector [being] a set of activities which are unified by some related product groups for a given or emerging demand and which share some basic knowledge" (Malerba, 2005). So far, the research in Sectoral Systems of Innovation (SSI) has mainly focused on sectors of industrial production, even though the framework has also recently been adopted in studying more knowledge-intense sectors (Breschi and Malerba, 2005), in particular, biotech (Cooke, 2002a), pharmaceuticals (McKelvey and Orsenigo, 2001) and IT (Ferrary and Granovetter, 2009).

Examining Innovation Networks

We propose to use ego-centric Social Network Analysis (ego-SNA) (Scott, 1988)to analyse the innovation networks of (key) studied companies. Our work here follows the approach of Giuliani (Giuliani, 2007a, 2007b), who have been researching knowledge networks and their ability to acquire and deploy knowledge in order to innovate. Though we are more interested in the process of innovation, in particular, the direction of the "knowledge flow" and the level of networks' integration in the NPD process, the examined qualities are similar (Giuliani and Bell, 2005).

The focus of this part of the inquiry is on mapping the relationships between the studied firms and its partners, in particular partner's importance for the studied company, which is measured both in subjective terms (ranked on a 1-5 Likert Scale by the interviewee) as well as by collecting information about frequency and depth of the connection (in terms of the number of employees within the studied company who are engaging with said partner). This is then analysed in conjunction with the qualitative data about the firms' NPD processes.

Furthermore, as the aim of this study is more specifically the qualitative description of the absorptive capacity within the NPD process, special attention is being paid to the knowledge flows and their direction. Data was also collected on the typologies of collaboration with respect to "purpose" (i.e. is it about R&D, business development (BD) or commercial interests); "nature" (i.e. the degree of formality and depth of involvement – for instance transaction vs partnership, type of partners involved); and the "result" (i.e. knowledge flow - IP ownership) of firms' relationships with external partners. Though some of this data will be discretely plotted in the individual firm's ego-SNA network map, most of this information will be summarised and contrasted qualitatively. This part of the data collection is based on interviews using a closed questionnaire, with multiple-choice answers, but options for other (more expanded) answers as well. This survey is fully incorporated in the "data matrix" and is filled out with a mix of discrete conceptual (e.g. frequency of contact, types of relationship, etc.) and numerical categories (e.g. Likert scale of importance, number of staff interacting with partner, etc.).

After plotting and examining the innovation network for each of the selected typical cases of the studied companies, the networks from all actors across the sector are to be combined into a composite whole socio-centric innovation network of all Scottish New Space SMEs. This is achieved by cumulatively mapping all the ego-net ties (i.e. connections) on one network map (Haythornthwaite and Wellman, 1996) and can then be subjected to a variety of SNA statistical tools to asses individual actors' network centrality. In particular, undirected eigenvector centrality can be used to sort the actors (network nodes) according to their position within the composite whole network. Such a measure of centrality can be used to demonstrate which actors are integrating the studied (innovation) network and correlated to qualitative data to analyse the reasons for the positions they occupy.

Mapping Out NPD Processes Through "Innovation Moments"

In order to analyse these network structures with respect to the effect(s) they have on the NPD process, we developed a qualitative section to our study based around identifying and examining the previously outlined "innovation moment", here used as a "sensitising concept" (van den Hoonaard, 2008) to standardise the data collection in the presence of a diverse set of ontological phenomena (Blumer, 1954). As described earlier, the proposed "innovation moment" framing is reflecting a wide variety of theoretical conceptualisations as outlined earlier, as well as having a degree of interpretative flexibility (i.e. not applying directly to any single theory) and can be easily explained through specific operational functions (i.e. using common language and specific examples). In particular, it contains embedded structural questions about the operation of the firms NPD processes, which is the objective of the research into the link between external open innovation networks and internal structural absorptive capacity. A schematic diagram of the "innovation moment" conceptualisation was presented in Figure 9 earlier, including its contextualisation as a problem-solving exercise within the wider analysis of organisational (knowledge) management within SMEs.

The data collection stage here was to ask specific questions relating to the formation of a "problem definition", following through "expertise gathering" and "solution formation" towards "integration" in the next phase of NPD process, at which point the cycle is repeated. This structure enables maximum attention to be paid to the involvement of external actors within the NPD process, as it respectively examines identification, acquisition, selection and alignment of internal and external resources. We asked each of our interviewees to talk about two R&D projects and to think about five to seven "innovation moments" for each. The informants are then asked to describe these key instances by outlining what a specific "moment" had been about, how the R&D/BD team framed it, how they looked for "solutions", how they picked the "solution" they considered best under the circumstance, and how that "solution" was integrated in the product/service being developed. A particular focus was on the engagement of external partners and the way in which the NPD process is structured and managed, which were extracted and analysed in a later section.

Selecting the Case Study

The emerging Space Sector in Scotland is providing an excellent platform for this research. In selecting the case study, we decided to use the geographical framing of Scotland due to the size, comprehensiveness, homogeneity and dynamism considerations, and the sectoral framing of Space Industry. The sector is analytically defined through product groups, which can be either split along different technologies, such as satellites, transmitters, detectors and data management systems or applications, such as earth observation (EO), telecommunications/broadcasting and satellite navigation.

With the help of gatekeepers and by attending over 30 open industry events, we have identified all of the sector's core SMEs and conducted a detailed mixed-method analysis of their innovation network and NPD process, using the methodology outlined above. Detailed analysis of the companies in the Space Sector in Scotland led to the identification of nine types of SMEs which can be categorised using double-crossed qualifiers as a set of typical cases (Yin, Bickman and Rog, 2009), see Table 4 below, which was based on a previous scoping exercise (Vidmar, 2015). The qualifiers applied relate to the level of maturity of the examined firms, which emerges as cross-correlation of size and age of the SME, and its position in the value chain, broadly described as upstream, mid-stream and downstream respectively. The latter qualifiers were derived from the standard-bearing OECD analysis of the Space Economy (OECD, 2007b).

	Software	Sub-systems & B2B Services	Hardware
	Down-stream	*Mid-stream*	*Up-stream*
"New Space" / Emerging (established since 2012)	ND	NM	NU
"Transitional" / Consolidated (established 2002-2012)	CD	CM	CU
"Classical" / Established (before 2002)	ED	EM	EU

Table 4 - A table of nine typical cases for Scottish Space SMEs' analysis, categorised by value chain position (down-stream, mid-stream and up-stream) and the length of presence in the sector/industry outlook (established, consolidated, emerging).

Results: Emerging (New) Space Sector in Scotland

The key empirical findings from the deployed two-fold inquiry are presented in the two sections below. We begin by examining the innovation network aspect, followed by the analysis of the NPD process, before bringing it all together and contextualising the findings within the examined literature in the discussion section. We focus in particular to the nine selected typical cases.

Emerging Innovation Networks

The dynamics of the nine ego-centric innovation networks show clear indications of significant structural changes in the size and characteristics of the innovation networks, as one compares the "classical" versus New Space aligned companies, as well as defining differences between upstream (hardware) and downstream (software) segments of the value chain, as seen in Figure 10[16]. The ego-centric SNA innovation network graphs clearly show differences in size, composition and geographical density of the innovation networks

[16] Mirroring Table 4, the graphs are organised from the "classical" on the bottom, via the "transitional" in the middle and to the "New Space" on the top and from "upstream" on the right through "midstream" in the middle and "downstream" on the left.

from the "classical" towards the New Space companies, with underlying upstream-downstream background differences notable as well.

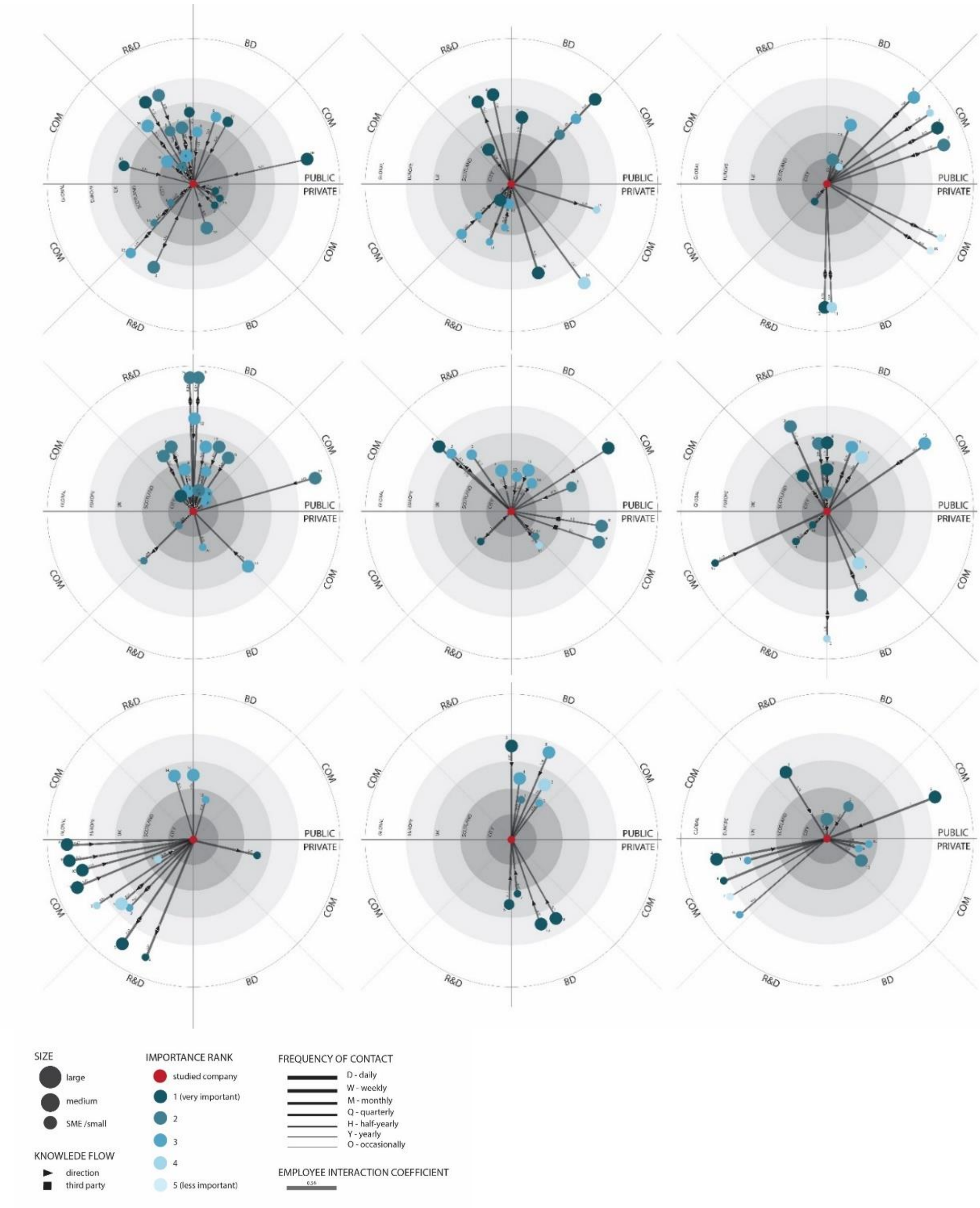


Figure 10 - Ego-centric innovation network maps for nine typical cases of the studied SMEs.

The networks are getting larger in the direction from established "classical" hardware SMEs (EU) towards the emerging New Space companies (ND). Similar trends were discovered in the public- to private- sector partnership ratios, and the levels of commercial activities, R&D and BD (i.e. relationships' "purpose"). The more New Space a company is, the more it partners with public organisations for R&D, BD and commercial transactions, and the more such partners it has. In contrast, more "classical" Space companies have more private sector partners, mainly engaged in purely commercial activities, such as distributors and suppliers. This trajectory is graded with the "transitional" companies (CM-type) in a clearly intermediate position, with a moderate degree of openness of innovation, network size and structure, and matching NPD characteristics.

Geographical proximity is often considered as an additional measure of strength (Davenport, 2005; Asheim, Boschma and Cooke, 2011; Cooke, 2012) and we observed that the "classical" Space companies have a much more global network in comparison to the New Space ones, for which the network density is much higher in the city of origin. Scottish cities, due to their highly educated workforce and good provision of facilities and services, are commonly seen as an asset for developing and growing high-tech clusters, for example, biotech (Leibovitz, 2004). Specifically, during the qualitative interviewing, one of the interviewed CTOs (from the ND firm) noted:

> *"When I go to Harwell [the definitive UK Space cluster] there is a lot of Space companies clustered together, but it is just Space […]. I think what Scotland needs to champion is the idea that our Space Industry is embedded in larger entities – which is the cities. […] I think what Space needs to do is to move out of the Space Industry and into these other sectors and I don't think that is something you can do in a campus environment like at Harwell, it needs to be in a city environment where they are surrounded by other non-related sectors."*

All studied firms had an even mixture of strong and weak ties (both by qualitative assessment on Likert scale as by quantitative measures of frequency and depth of interaction). The ties typology ("nature") has also changed, but insignificantly with a clear dominance of formal/contractual relationships, though New Space firms mentioned having informal relationships in addition to formal ones. However, weak yet significant differences are noted in formal "knowledge flow" measured by sharing of IP, though very much depending on value chain position. In the downstream segment, there is no detectable change between SMEs' generations (ED, CD, ND), whereas in the upstream part (EU, CU, NU), there are significantly more joined or third party IP ownership arrangements amongst the younger, New Space firms.

Finally, when examining the whole network (see Figure 11 and background data in Annex 2: Core Innovation Network Data Table) we note that the central role in this regional sectoral network is occupied by a series of public stakeholders, agencies and institutions (European Space Agency, UK Space Agency, Scottish Centre of Excellence in Satellite Applications, Scottish Space Network, Innovate UK, Scottish Enterprise, etc.) who intermediate in the innovation process, pointing to an increasing importance of public R&D and BD support for New Space SMEs. This is also apparent from the firm-level network expansion into the public sphere, as noted in the firm-level ego-SNA analysis.

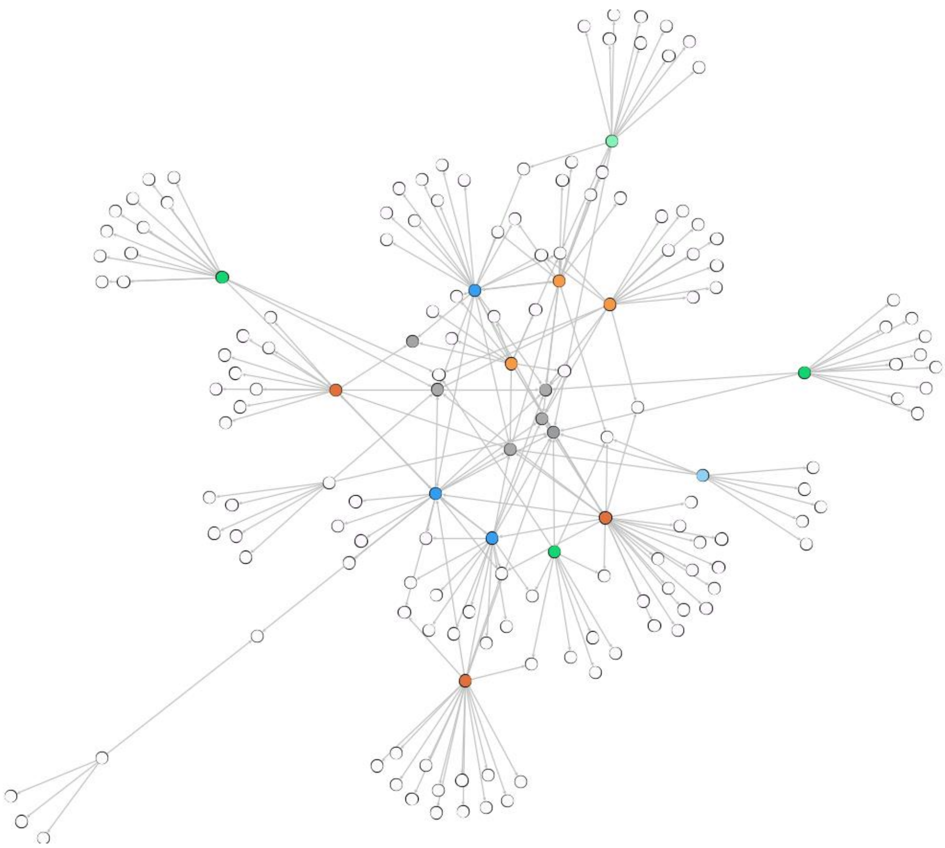


Figure 11 – The composite whole Scottish Space Sector innovation network.

In addition, some notable consolidated companies (CU and CD -type in particular) were also found to be very centrally positioned in the composite innovation network, being most dominant in the process of developing the current vision for Scotland's Space Industry integration around a joint loose value chain, also referred to as "Agile Space" (Vidmar, 2019b, 2020). Furthermore, the expansion of the sector is seemingly driven by external forces, as it does not couple very closely with the initial sectoral core (EU, EM and ED type firms).

This indicates the importance of the transition to New Space's open innovation model for the network structure, since it is adopted by the centrally positioned emerging and consolidated firms. On top of that, there is also significant role of interventions by innovation intermediaries in the network structure, as noted by their central bridging position.

The Changing NPD Processes

When moving to qualitative data, analysed through the framework of Open Innovation (Chesbrough, 2006), we again find a very clear divide between upstream and downstream; and "classical" and New Space, as EU-type companies tend to exhibit more "closed" innovation models than ND-type ones. Analysis of all of the firms' NPD processes suggests that the more the innovation process is "open" the less hierarchical it is, but also the more structured/standardised and formalised in well-defined "phases", such as defining requirements, exploring technological limitations, prototyping, engaging with clients, etc., as seen in Table 5. This is in line with anecdotal experience from most successful high-tech areas, where more formalised, yet less restrictive NPD protocols are being established in order to capitalise on as much innovation as possible (Neapole, 2005).

Such organisational changes were be identified by two interrelated trends, the NPD teams are larger and more diverse and crucially, the firms are breaking down the traditional workplace hierarchies. Instead of the firms' management teams leading the process directly (like in the case of ED, EM and EU), the youngest, New Space companies (ND, NM and NU) only coordinate the development of NPD structures from the top - i.e. road-mapping, development of work allocation and procedures - whilst day-to-day innovation work is handled by a dedicated new role of "project manager" or "developer". This enables a greater and more successful integration of interdisciplinary expertise and more diverse engagement of internal and external partners through "relationships management". Smaller firms also highlighted the emerging need for "subcontractors management", recognising similar requirements to manage transactional costs and the challenges of outsourcing any part of NPD.

These organisational management changes are also related to the emerging dominant commercialisation strategies, which are moving away from IP protection regimes and towards first- to-market and product differentiation as unique selling points (USPs). This is likely due to the changing balance from engaging in a “technology push” business model, with dominance of business-to-business customer relationships, towards a more “market-pull” model with a wider array of clients, i.e. selling to the “end user”. When examining the products developed within studied firms, the latter model seems to lead to products with a lower level of technological advantage (i.e. “incremental innovation”), but with an increase in knowledge complexity (i.e. additional incorporating product design, behavioural science, marketing, etc.) and yet at the same time also user-friendliness (i.e. ease of use, ease of installation and integration with existing technologies, wide distribution, etc.) – leading to very competitive market position.

	Software	**Sub-systems & B2B Services**	**Hardware**
	Down-stream	Mid-stream	Up-stream
"New Space" / Emerging (established since 2012)	Structured NPD process including well-defined stages (user-defined requirements, technical requirements, prototype, beta release, etc.) Specified Project Manager role for coordination and oversight	Structured NPD process with defined phases (defining requirements, identifying potential technological solutions, clarifying client needs, defining the product, development, prototyping, testing, release) The whole company (8 people) involved in coordinating all projects, but with management leadership	Started unstructured, but now a structured NPD process, with well-defined phases and template documentation Self-nominated Project Manager (whoever starts the paperwork) leading the development
"Transitional" / Consolidated (established 2002-2012)	Semi-structured NPD process (processes in place, such as regular meetings and briefings, but phases differing from project to project) Management oversight, but led by project developers (engineers)	Semi-structured approach (defined phases, but informal), key stage "productisation" for ease of use and mass production, adopting software NPD process methods Management team has strong oversight	Structured approach for some projects (core business) and unstructured for others (pathfinders) Project development lead for pathfinder projects, but with strong management control
"Classical" / Established (before 2002)	Unstructured NPD process (ad hoc project development) Management oversight and control of NPD	Unstructured NPD process (significant difference between projects) Strong management leadership and control	Started very unstructured, now semi-structured NPD process with very loose and informal stages (design, prototyping, testing) Management team in control of NPD

Table 5 - Structure of NPD processes and their management within the nine case study SMEs

The deliberate decision to develop such business models was fully acknowledged by most of the New Space companies in the sample (ND, NM, NU) and the wider population, with explicit comparisons drawn to competitive markets such as video streaming (i.e. "becoming the Netflix of EO data") and their sales techniques, for instance creating programme loyalty, defining unique selling points and niche exploitation. Furthermore, the process of delivering products and services to the market, as well as their positioning in those markets, was described in terms of defining user requirements. For instance, working with lead users to test pipelines and package products as platforms, to allow for maximum flexibility and continuous updates and upgrades (as short as 4 months and 6 months product improvement cycles were cited). This approach is being adopted by the consolidated-type firms as well, as the CD's representative underlined that they are now looking at developing products "not for a client, but for a market". Transitional CM's CTO picked up on the same trend, noting that his firms is changing: "instead of fixing requirements, accommodate for the fact that things change".

Such an "agile" approach to NPD also translates into SMEs' business model flexibility, as several of the studied SMEs started in education markets, from where the core New Space R&D emerged. However, soon they moved to commercial opportunities within other domains, in particular agri-tech and financial markets, the latter particularly notable in the NU-type companies. Likewise, several downstream firms (CD-like and ED-like) moved from Earth Observation analytics for environmental protection towards agri-tech, too (Vidmar, 2019b). Interestingly, these trajectories are similar regardless of whether the companies were spin-offs from research or entrepreneurial start-ups. Though some of the smaller firms analysed look for any new opportunity to supplement their portfolio of projects and revenue streams, many of the companies developed their "vision pitch" to position themselves in a well-defined (niche) market. Crucially, most downstream companies, in fact, do not highlight their Space and Satellite credentials, but prefer to highlight competencies in data analytics instead.

In contrast, the upstream firms do emphasise their high-tech Space Industry credentials and appreciate the value of an endorsement from big players in this arena, in particular, the European Space Agency (ESA). Though they often find engaging with ESA challenging - due to the Agency's complex policy framework(s) as well as significant project management requirements leading to bureaucracy - ESA certification through participation in R&D

programmes, subcontracting or the adoption of quality assurance standards is desired by most New Space upstream firms.

Discussion: Diffusion of Open Innovation through Embedding Absorptive Capacity into the NPD Processes in the Geographically-Bound Sectoral System of Innovation

From combining SNA and "innovation moments" analysis, it is clear that a significant link exists between the shape and size of an SME's innovation network, their centrality in the regional sectoral network and the structure of their NPD processes. Specifically, the level of formalisation of the NPD process - with clearly defined roles and procedural steps, complete with detailed paperwork trail and resources management measures - corresponds to SMEs establishing and maintaining a larger innovation network of varied partners. This brings more significant knowledge flows across the organisational boundaries and their more central location within the regional sectoral network.

In line with this papers' main objective, we hence put forward a perspective of the absorptive capacity as a structural property of the SMEs' organisational behaviour, contributing to firms ability to connect into (a receptive) external environment. This is the basis for the firms' absorption of knowledge in a more "open innovation" fashion, through engaging in knowledge exchange with academic institutions and researchers (Wright, Birley and Mosey, 2004; Deschamps, Macedo and Eve-Levesque, 2013), enrolling lead users in development to actively shape products and services (Urban and von Hippel, 1988; Hyysalo and Stewart, 2008), and participating in a variety of opportunities to explore competing options for market formation and pathways to commercial exploitation of R&D (Lee *et al.*, 2010; Chesbrough and Bogers, 2014). Such wider, system-based innovation/R&D operations are also linked to more intensive support by innovation intermediaries (Agogué, Ystrom and Le Masson, 2013; Vidmar, 2018), also noted for their centrality within the analysis of the Scottish Space Sector's innovation network outlined earlier. One would be tempted to propose that as a consequence, the structural framing of absorptive capacity is more independent of the traditional measures of geographical and cognitive proximity, as it is deliberately shaped through organisational structures within firm management. Though the availability of external knowledge is an important consideration to shape the environment within which the organisational behaviour is to take place and is crucial in enabling its success, the structural organisation is vital for the SMEs to successfully seek, identify, select and integrate the knowledge needed in their NPD process. This would relate to the critical role of management teams in encouraging absorptive capacity as noted by previous studies (Jones, 2006; Zahra and Filatotchev, 2009; Lewin, Massini and Peeters, 2011).

However, there seems to be an uneven uptake of the open innovation approach within the studied sample, as the upstream firms, even the younger ones, are exhibiting these structural changes less strongly. In fact, the recruitment model of knowledge acquisition (Herstad, Sandven and Ebersberger, 2015) is still quite prevalent within most of the upstream firms. This is in part be related to the nature of the technological challenges they face, the structure of their markets and competitors, and other cultural differences related to varied "epistemic cultures" (Knorr-Cetina, 1999) between the hardware upstream manufacturing and the software downstream application development. The latter is a particularly interesting observation, since the downstream firms, operating within the broader ICT sphere, tend to exhibit many of the features of the entrepreneurial culture of the ICT sector in the 2000s and 2010s (Lee *et al.*, 2000; Jaruzelski, Loehr and Holman, 2011; Engel, 2015). This includes a relaxed workplace environment, flatter management hierarchies and a set of measures to "boost innovativeness and creativity" (Roffe, 1999). This "culture" is becoming pervasive across the New Space segment of the Scottish Space industry, as even one of the NU-like firms' CEOs interviewed specifically commented on their approach to innovation within the firm as: "follow your nose and get creative!".

Hence, in terms of developing the absorptive capacity itself, we suggest that organisational learning has in fact occurred along geographically and cognitively proximate domains, similarly to previous findings (Boschma and Frenken, 2011; Cooke, 2012). In our case, this occurred in two phases: firstly, through the downstream New Space companies, as they most closely align with the IT sector from where many of these ideas originate, and from where the NPD process management features described here likely originate. Secondly, these lead firms' share geographical proximity and sectoral identity with mid-stream and upstream SMEs within the examined GSSI, through which they further diffused their new insights into NPD management and other aspects of the emerging "innovation culture". In particular, one of the studied "transitional" firm's (CM) CTO specifically mentioned: "[…] it's about taking things [NPD management practices] from app developers and applying them to hardware." It is clear that this is being spread further up the value chain as well, since the NU's CTO described their NPD process as "applying design thinking to hardware", specifically taking ideas from Silicon Valley and basing their approach on "empowering people to compete". An example of this is their change of the NPD process from unstructured and management-led towards more structured and with self-nominated project managers ("whoever starts a document is in charge of it").

These trends also correspond to the emerging Agile Space conceptualisation of the sector's value chain integration, which is being proposed by a series of lead players in the middle/consolidated generation of the Scottish Space actors, in particular firms of the CD and CU type. These are New Space trends adopters, who have already established the critical size and sectoral position to influence other firms. Their efforts are based on their vision to achieve a cross-regional vertical value chain integration as a loose consortium of SME-type firms, making Scotland a one-stop-shop for space assets, yet ensuring greatest possible flexibility, openness of the system (notably in its ties to academia) and resilience in face of competition (Vidmar, 2019b). Thereby the highly projectised NPD process serves as the enabling organizational principle for inter-firm linkages, supported by an extensive, dense and centrally integrated cross-sectoral network.

Conclusions and Further Research

The main aim of this paper was to illuminate a the transition towards open Innovation by the changing structure (size and composition) of SMEs' innovation networks and changes to the structure of NPD processes, as points of absorption of knowledge into the firm. This has been examined through the combined ego-SNA mapping of innovation networks and qualitative analysis of NPD processes through the newly developed conceptual tool of "innovation moment", bridging the meso-level networks and micro-level processes and deployed as a "sensitising concept" within a case study of a geographically-bound sectoral system of innovation.

When studying the Scottish Space Sector through the proposed framework of combined NPD-network analysis, we are seeing a very clear graded transition trend between upstream and downstream, and "classical" and New Space firms. Upstream "classical Space" companies tend to exhibit smaller though more global and commercial innovation networks and more hierarchical and erratic NPD process than downstream New Space companies, which have larger yet more local networks with more public organisations as partners. They also have more standardised and formalised NPD, breaking down hierarchical organisational structures, but with clear management strategies. Finally, the whole network analysis shows how central positions are occupied by more New Space companies (with slightly more established firms taking a lead over the new entrants) and a critical network integration role for innovation intermediaries.

On the basis of these empirical findings we examined the role of absorptive capacity (Cohen and Levinthal, 1990; Zahra and George, 2002; Sun and Anderson, 2010) in Open Innovation (Huang and Rice, 2009; Lee *et al.*, 2010; Chesbrough, 2011), and its processual operationalisation through NPD structures, which we found to be transferred from other recently emerging high-tech sectors. We identified an emerging trajectory for such adoption through organisational learning, transferred across geographical and cognitive boundaries, from the cognitively adjacent ICT sector, through downstream Space SMEs, and towards the geographically proximate upstream Space firms. These results demonstrate a significant alignment between expanding innovation networks and increased projectification of NPD processes, leading towards a structural construction of absorptive capacity. In addition, the mapping of the whole innovation network also points towards key roles for innovation intermediaries and consolidated firms in promoting organisational learning and developing these systemic capabilities. For instance, on top of expanding the "open innovation" approaches within the sector, they are also driving the establishment of a collective vision of a loosely co-joined vertical value chain integration, a systemic model through which Space Industry in Scotland is establishing a globally recognisable brand (Vidmar, 2020).

This was brought about through key players adopting a more "agile" business models, in order to dynamically respond to new customers and markets (Vidmar, 2019b). Such an approach is made possible through adaptation of the firms' "innovation culture" to be able to quickly address these new opportunities, in ways adopted from most dynamic sectors. Specifically this is done through deploying novel NPD process management techniques[17], which are developing absorptive capacity and expanding their innovation networks. Having established and tested our novel conceptual framing of "innovation moments", we believe it

[17] Additional ethnographic evidence shows an ever broader cultural impact, for instance, most of the New Space firms visited have architectural features and furniture in their offices which are intended for relaxing or play as well as communal meals (for instance billiards or football tables, bar/kitchen, lounge/common room, outdoors areas, etc.). This is in stark contrast to the "classical" Space companies, whose premises do not have these features.

can be used to explore this transition in any geographically-bound sectoral system of innovation domain.

Though this study aimed to be as comprehensive as possible, the relatively small population of Scottish Space SMEs limited the ability to infer results by deploying statistical measures or to propose strong correlations between the examined elements. However, we believe that the identified trends and the advancement of the methodological approach to the study of these phenomena constitute a significant original contribution to the understanding of open innovation in SMEs. It shows absorptive capacity through innovation networks, while it also provides some crucial insights in the development of the Scottish Space Sector.

In terms of possible further research, we propose to examine comparable cases elsewhere. With the goal of developing understanding further, the “innovation moments” conceptualisation combined with the multi-level methodology developed and presented within this paper are suitable to further illuminate the mechanics of building “absorptive capacity” within firms through organisational learning trajectories. To do so, a more detailed theoretical development on the links between “innovation moments” and the absorptive capacity and innovation network frameworks are needed. Furthermore, some of the key transformative network elements and organisational management principles which have been outlined here, require further empirical examination to understand their exact origin, characteristics and effects. As mentioned, this is particularly true for innovation intermediaries, who play a pivotal role in the development of this emerging New Space innovation.

Annex 1: Outline of the Empirical Work

The empirical work is based on an in-depth analysis of all Scottish Space Sector core SMEs, in particular their NPD and engagement with other actors in their innovation networks. A list of Scottish Space Sector SMEs was compiled using publicly available data, gatekeepers intelligence and a multi-criterion filter consisting of:

- conforming to SME firm description (fewer than 250 employees, less than £25M turnover and less than £12.5M in gross assets),
- are based in Scotland (according to Companies House data),
- one of core business/product/service groups falls within the Space Economy value chain,
- they are actively developing new products and are near completion on at least one NPD project by end of 2017, and
- they are economically active and have a noticeable presence within the sectoral ecosystem (attending conferences and other events, updated website, filling annual tax returns).

This led to the list of the following Scottish Space Sector companies: Alba Orbital (PocketQube Shop), Astrosat, Bird-I, Bright Ascension, Carbomap, Clyde Space, Ecometrica, GSiCarbon, Orbital Access, PHS Space, Sidereal Space Imaging, Spire, Star-Dundee, Veripos, ThinkTank Maths, TLS International and Topolytics. I have carried out in-depth interviews (up to 2h) with a member with each of these firms' management team (CEO or CTO). In line with the research objectives, I have been asking specifically (see

Appendix D: SME's Interview Schedule and Appendix E: Data Matrix for details):

a) How does the company source knowledge/technology/business development skills? What kind of knowledge is transferred (tacit, codified, skills, experience, etc.); How is it transferred (informal contacts, (research) partnership/collaboration, recruitment, IP transactions)?
b) What/who is the main source of new ideas/technology/business development? Who are the key external contacts (actors)? What kind of role does the company play in the regional/sectoral network and how does that change? (Using ego-SNA)
c) When and how do these sources feature in company's NPD (R&D and BD inclusive)?
d) Provide a description of (complete) NPD. Describe stages/processes/structure; who is involved (in which part); what kinds of problems/themes are addressed (and in what sequence)?

Additional (non-structured) input was obtained from a variety of other actors in academic and research environment: University of Strathclyde, University of Edinburgh, University of Dundee, Scottish Satellite Application Centre of Excellence, UK Astronomy Technology Centre, Dundee Satellite Receiving Station; from bigger firms: Leonardo, BAE Systems, Axxon Cable, etc., public bodies and development initiatives, for instance: Prestwick Spaceport, Scottish Space Network, Scottish Enterprise, Highlands and Islands Enterprise, Skills Development Scotland, etc. I have also attended over 30 industry events across Scotland, UK and globally, collecting information from a variety of stakeholders.

Annex 2: Core Innovation Network Data Table

Table 6 contains colour-coded data on the all central nodes within the composite Scottish (New) Space Sector network (presented at Figure 11), as sorted by eigenvector centrality, up to the cut-off point of encompassing all nine typical cases SMEs. This list clearly both validates our sampling method, as the all the key typologies appear in sequential order, as well as shows the core of the network positionality and influence distribution trend from consolidated downstream to upstream and from "traditional" to "New Space" firms. The slight dominance of the "transitional"/"consolidated" firm class is related to level of maturity (N-type are too young to have central network role) and the relative completion of transitional arrangements into New Space (C-type have led the transformation and now behave as New Space firms).

Identifier	In-degree	Out-degree	Degree	Authority	PageRank	Undirected Eigenvector Centrality (sorted)
CU	5	15	20	0.0345	0.0686	1.0
ND	1	24	25	0.0521	0.0200	0.9300
CD	2	21	23	0.0427	0.0303	0.8977
Intermediary 1	11	0	11	0.0213	0.0727	0.7546
Intermediary 2	8	0	8	0.0151	0.1607	0.6661
CM	2	14	16	0.0305	0.0429	0.6438
ND-like 1	0	12	12	0.0233	0.0530	0.5825
Intermediary 3	8	0	8	0.0152	0.125	0.5644
ND-like 2	1	14	15	0.0275	0.0330	0.5524
NM	0	19	19	0.0432	0.0117	0.5338
Intermediary 4	6	0	6	0.0112	0.1333	0.4769
Intermediary 5	6	0	6	0.0121	0.0667	0.4706
NU	2	13	15	0.0316	0.0110	0.4263
University 1	4	0	4	0.0080	0.4167	0.3975
ND-like 3	0	16	16	0.0344	0.0	0.3795
University 2	5	0	5	0.0097	0.2000	0.3557
ED-like[18]	1	12	13	0.0301	0.0064	0.3015
Big Corporation	4	0	4	0.0081	0.0	0.2563
Intermediary 6	3	0	3	0.0062	0.1666	0.2456
CM-like	0	8	8	0.0181	0.0	0.2434
EU	0	12	12	0.0307	0.0	0.2323
EM	0	10	10	0.0215	0.0	0.2248
ED	0	14	14	0.0354	0.0	0.2087

Table 6 - Whole Network Data Table (up to all case studies)

[18] This SME exhibits "mixed behaviour" as though it is an "established" firm, its Space-specific offer has only been developed recently within a small cluster of projects led by a new young team, who behave more like an ND-like company.

PART 2 - THE ROLE OF INNOVATION INTERMEDIARIES

Chapter 4: Innovation Intermediation - Towards a Functional Classification of Interventions

Introduction

The focus of economic and industrial development has now shifted towards small and medium-sized enterprises (SMEs), due to the increasing recognition of entrepreneurial and R&D drivers for economic activities (Neffke *et al.*, 2014; Wright *et al.*, 2015). As SMEs are more dependent on external support in innovation processes, they can best be studied using a contextual/network approach which shows their interaction with other actors (van de Vrande *et al.*, 2009; Lee *et al.*, 2010; Pullen *et al.*, 2012). In particular, the innovation systems approach (Freeman, 1991; Cooke, 2001; Malerba, 2002; Hekkert *et al.*, 2007) provides a comprehensive conceptualisation of the systemic nature of innovation, as it examines it as an inter-organisational and context-dependent activity. Consequently, they provide a good analytical lens to study the innovation activities of SMEs as well as those actors who support them.

Support of SMEs is being provided by a variety of organisations referred to as “innovation intermediaries”. Looking at definitions of innovation intermediaries, a substantial focus on “knowledge brokerage” can be found in the literature, while other studies have analysed a variety of roles intermediaries play in innovation systems. This has led to the concern that although the innovation intermediaries literature is well established, it is, as explicitly noted by many authors, currently too fragmented and limited in understanding available interventions (Van der Meulen *et al.*, 2005; Howells, 2006; Dalziel, 2010; Abbate, Coppolino and Schiavone, 2013; Hannon, Skea and Rhodes, 2014).

Although several attempts have been made to bring different approaches to innovation intermediaries closer together, feedback from both scholars and practitioners indicates a continued lack of clarity and operational applicability. This is particularly evident in addressing more programmatic and normative questions, such as: what should an intermediary do to achieve a certain result in a given context? Similarly, scholars often struggle to ascribe specific systemic roles to individual intermediaries, as their engagement in a targeted economic unit (in most cases a geographically-bound sector) seems either too scattered or too unspecific/broad (Hannon, Skea and Rhodes, 2014).

This paper identifies a key gap in the innovation intermediaries literature: the lack of an inclusive and complete functionalist classification of available interventions. It is evident that further systemisation of the literature is needed to provide a deeper understanding of the roles of innovation intermediaries and to offer concrete policy proposals (Smits and Kuhlmann, 2004; Klerkx and Leeuwis, 2008; Dahlander and Gann, 2010; Katzy *et al.*, 2013). To address this challenge, this paper outlines four key developments. Firstly, it systematically reviews intervention intermediaries' literature to propose to advance a pragmatic definition of innovation intermediaries. Secondly, based on a systematic literature review, it establishes a de facto geographical and sectoral framing of innovation intermediation research. Thirdly, it shifts the focus away from organisational configurations and towards available intervention types. Finally, it proposes an inclusive classification framework of interventions, based on examining the key dividing lines between systemic literature reviews (Howells, 2006; Dalziel, 2010; Kilelu *et al.*, 2011; Nilsson and Sia-Ljungström, 2013; Kivimaa, 2014; Kim, 2015; Lukkarinen *et al.*, 2018) and additional studies. The proposed model is then successfully retrofitted to an array of past studies, pending further empirical validation.

Defining Innovation Intermediaries

Innovation intermediaries can be defined in many different ways. The emergence of a systemic study of this field can be traced to seminal work by Howells (Howells, 2006). Their premise is that an innovation intermediary is:

> *"An organization or body that acts as an agent or broker in any aspect of the innovation process between two or more parties" (Howells, 2006, p. 720).*

Howells bases this definition on a very large review of case studies, which suggests that intermediaries' primary roles are multi-party (knowledge) brokerage (Howells, 2006) (see Annex 2). This rationale is further underpinned by the observation that key processes of open innovation (Helfat and Quinn, 2006; Chesbrough, 2011; Chesbrough and Bogers, 2014), in particular at SME level (Lee *et al.*, 2010), are based on interaction with external partners (West and Bogers, 2014). Knowledge dissipation, in particular, is done through such interlinking between individuals and organisations (Brown and Duguid, 2001; Malerba, 2005). Hence (open) innovation is crucially linked to the network of external partners from whom a company can source knowledge and/or with whom it can share its own resources (Tidd, Bessant and Pavitt, 2005; Iturrioz, Aragón and Narvaiza, 2015). This is a key element of the innovation systems view of open innovation, of which a key component is the "knowledge network" and its density or interconnectedness (Pittaway *et al.*, 2004; Inkpen and Tsang, 2005; Kim, 2015; Simard, 2015).

Building on the importance of knowledge brokerage, an SME's ability to share and absorb knowledge from an (open) innovation network is seen as a precondition for regional industrial development (Von Tunzelmann, 2009). It follows that pathways through which the knowledge is brought into an innovation network or transferred across sectoral and technological domains also play a key role in the SMEs' innovation and NPD processes. Past studies highlight that new combinations of knowledge tend to happen at the interfaces of both geographically proximate and cognitively related domains (Boschma and Frenken, 2011; Cooke, 2012). To bridge these domains SMEs often need translational support, which intermediaries are providing in their knowledge brokering function (Howells, 2006; Kim, 2015).

However, a series of studies have also shown that intermediaries engage with their sectors far beyond the "knowledge brokerage" definition described above and that many interventions take on a wider systemic role (Smits and Kuhlmann, 2004; Dosi *et al.*, 2006). In particular, there is a significant amount of work demonstrating not only the breadth but also the depth of intermediaries' involvement in knowledge production (Hyysalo and Stewart, 2008; Agogué, Ystrom and Le Masson, 2013; Deschamps, Macedo and Eve-Levesque, 2013) and their hands-on support and management of collaborations and projects (Katzy *et al.*, 2013; Mgumia, Mattee and Kundi, 2015).

Furthermore, there is a plethora of research examining many other ways through which intermediaries support SMEs and their innovation processes. Crucial examples focus on support with "locating and approaching the customer, developing relationships of trust, accessing finance, effectively managing the firm, and training employees" (Vonortas, 2002); provision of specialist equipment (Mian, 1996); quality control, standards development and certification (Grindley, Mowery and Silverman, 1994; McEvily and Zaheer, 1999; Fuchs, 2009); providing physical space (Löfsten and Lindelöf, 2002); as well as engaging in sectoral brand development and developing regulatory (legal) frameworks (Sapsed, Grantham and De Fillippi, 2007; Boon *et al.*, 2011; Lukkarinen *et al.*, 2018).

The deployment of these resources and activities, whilst related to development and maintenance of a knowledge-based innovation network, are much more diverse than the "brokerage" function. Howells makes the distinction that knowledge-brokerage based innovation intermediation can be one of the functions of "organisations" providing wider innovation support (Howells, 2006). However, it is becoming clear from the studies listed in the previous paragraph, that these "additional" activities are an intrinsic part of systemic intermediation itself. Hence, I propose that a more inclusive definition is more appropriate in developing a holistic understanding of the variety and complexity of intermediaries' work. This is in line with Dalziel, who states that:

> *"Innovation intermediaries are organizations or groups within organizations that work to enable innovation, either directly by enabling the innovativeness of one or more firms, or indirectly by enhancing the innovative capacity of regions, nations, or sectors."* (Dalziel, 2010, p. 1)

This broader definition is also allowing for a variety of programmes enabling business development and market creation to be included. Dalziel, for instance, mentions industry and trade associations, economic development agencies, chambers of commerce, science (or technology or business) parks, business incubators, research consortia and networks, research institutes, and standards organizations (Dalziel, 2010).

I propose that in order for this definition to be helpful as to the purposes of greater clarity and systematisation. This is based on the multiple and varied functions identified in the literature review and the academic and practitioners' interest to comprehensively address the variety of functional roles innovation intermediaries undertake within innovation systems. Hence, I argue the definition should be further amended to state that:

> *"An innovation intermediary is an organisation or a group within an organisation, whose main objective is to carry out interventions enabling innovation, either directly by enabling the innovativeness of one or more firms, or indirectly by enhancing the innovative capacity of regions, nations, or sectors."*

This expanded definition crucially introduces a key new analytical marker namely the main purpose or objective, which is also corresponding to Howells (2006) notion of central and peripheral functions within many organisations in this arena and echoing Winch and Courtney definition, highlighting that innovation intermediaries are "focused neither on the generation nor the implementation of innovations, but on enabling other organizations to innovate" (Winch and Courtney, 2007, p. 751). In addition, the proposed new definition also specifies more clearly that an intermediary's work is to intervene in the system, with the variety of interventions aimed to enable innovation (including those moving away from brokerage) becoming the key objects of innovation intermediation research.

Innovation: The System(s) Approach

Scholarly interest in innovation and the economic role it plays is often traced back to Schumpeter's seminal work on entrepreneurship and wealth creation (Malerba and Orsenigo, 1995). Subsequent research can be divided into two main branches: examinations of the micro-level role of innovation in a firm and its relation to development and growth; and studies of macro-level economic and social theory, examining the effect of innovation on the economy and society as a whole (Pavitt, 2003; Swann, 2009). Most recently, a very successful paradigm for macro-level studies was created, namely the Innovation Systems (IS) framework (Freeman, 1991). This encapsulates most of the macro-level effects and has been adapted to studies of various different scales and purposes.

Specifically, it has been shown that the innovation systems model can be framed using geographical boundaries, such as the national level (Freeman, 1991; Georghiou, 1993; Nelson, 1993; Lundvall *et al.*, 2002); or the regional level (Cooke, Gomez Uranga and Etxebarria, 1997; Cooke, 2001; Asheim, Smith and Oughton, 2011). Alternatively, the model can be applied according to areas of economic activity, utilising either technological (Hekkert *et al.*, 2007; Bergek *et al.*, 2008) or sectoral (Malerba, 2002, 2004b, 2005) platforms. However, these different levels of enquiry share the same common framework of the Innovation Systems model, tailored according to the scope and aims of different researchers' interests (Frenz and Oughton, 2005). For example:

> *"Edquist (2004) has argued that system boundaries may be defined in one of three ways: spatially/geographically; sectorally; and in terms of system activities or functions."* (Asheim, Smith and Oughton, 2011).

In contrast, this paper argues that for detailed and complete (micro-level) studies of innovation systems, most authors de-facto adopt all three sets of boundaries to define the studied environment and roles of the various actors/players within them.

A detailed literature review was carried out using the Scopus database. The “innovation intermediary” search term returns 161 documents, of which 108 were journal papers. Given this study’s interest in “innovation systems” approach, it was established that about three-quarters of those 131 (89) also contain the key phrase “innovation system” and 104 (68) also contain the key phrase “open innovation”. Of all papers initially identified, 42 were deemed relevant for this review, based on the title, abstract analysis and availability to read and download via the University of Edinburgh library services. Further analysis yielded only a handful of studies, which are presented here, focusing on systemic roles and containing more than one single case study and/or a single intermediary function/role, hence, giving insights relevant for systemic classification framework, which is the aim of this paper. Additionally, key emerging themes included an overwhelming focus on knowledge and technology brokerage (which will be discussed later on) and recent interest in crowdsourcing and online intermediary platforms. However, the latter’s systemic role and value are harder to characterise (owing to novelty and somewhat selective applicability).

STUDY	GEOGRAPHY	SECTOR	FUNCTION(S)
Lukkarinen et al. (2018)	Finland	Cleantech	Alignment of interests, the building of capacities and the formation of markets
Lin, Zeng, Liu, & Li (2016)	China	Manufacturing	Absorptive capacity
Mgumia, Mattee, & Kundi (2015)	Tanzania	Agriculture	Demand articulation, network brokerage and innovation process management
Iturrioz, Aragón, & Narvaiza (2015)	Spain	Modragon cooperative	Social capital
Kivimaa (2014)	Finland	Energy	Political positions and roles of intermediaries in transitions
Nilsson & Sia-Ljungström (2013)	Sweden and Denmark	Food	Regional Innovation System Development
Agogué, Ystrom, & Le Masson (2013)	France and Sweden	Traffic safety engineering	Structuring collective exploration
Hargreaves, Hielscher, Seyfang, & Smith (2012)	UK	Community energy	Niche development
Klewitz, Zeyen, & G Hansen (2013)	Germany	Metal and mechanical engineering	Sustainability transition
Boon, Moors, Kuhlmann, & Smits (2011)	Netherlands	Health care sector	Demand articulation
Kilelu et al. (2011)	Kenya	Agriculture	Innovation brokering

Table 7 - Brief summary of some of the key empirical studies of innovation intermediaries since 2010, indicating the three defining boundaries: geography, sector and function(s).

When analysing recent empirical studies looking at innovation intermediaries within innovation systems (see Table 7 above), a key observation is that most studies take a sectoral focus, while also clearly defining a geographical boundary. For instance, Nilsson and Sia-Ljungström note this approach as “sector-specific regional innovation systems” (Nilsson and Sia-Ljungström, 2013, p. 161). Such specific framing is also apparent in some policy contributions (Bendis, Seline and Byler, 2008). Though recent empirical work on innovation intermediation on the basis of platforms transcends this compartmentalisation (Kokshagina and Masson, 2015; Hossain, 2017). They focus more on processes behind the operation of platform-based intermediation than on their effects as interventions in innovation systems supporting open innovation.

This paper argues that the de-facto framing of Geographically-bound Sectoral System of Innovation (GSSI), which I believe is the most accessible, comprehensive and homogenous unit of analysis. The GSSI's constituent actors share the same economic, political and social environment, whilst also supporting the required diversity and complexity to analyse both (generic) systemic interventions and sector-specific ones. Sectoral emergence dynamics, (sustainability) transitions, and systemic differences between sectors and/or geographies can also be very effectively exposed by this framing, as it can be used in empirical studies to compare case studies between places, before and after timelines and contrast different sectors.

Moreover, the functionalist boundaries of these studies present a critical challenge to the innovation intermediaries literature, as they are very varied and do not easily fit a single comprehensive systematisation of all deployed roles and functions. Most of the studies examined focus predominantly on the networking and brokerage functions and facilities within the GSSI framing, and are not proposing to develop an all-encompassing model of intermediation. This leads to a lack of clarity amongst practitioners and scholars alike as to what innovation intermediaries as a whole are or can be (Van der Meulen *et al.*, 2005; Howells, 2006; Dalziel, 2010; Abbate, Coppolino and Schiavone, 2013; Hannon, Skea and Rhodes, 2014).

To summarise the analysis in the previous sections, there are many different types of intermediaries functions and in most cases, their work spans several categories of resources provision and active participation in an innovation system. Furthermore, intermediaries' roles change due to a myriad of external and internal factors and evolve as an innovation system is developing. Arguably, their role is most crucial in the early (emergent) stage of an innovation system (Antikaninen, Mäkipää and Ahonen, 2009; Agogué, Ystrom and Le Masson, 2013; Katzy *et al.*, 2013), but there are many roles they can (and do) fulfil in mature systems as well (Vonortas, 2002; Boon *et al.*, 2011).

From Intermediaries to Interventions

As such, I argue argues that more pertinent and central to the understanding of the innovation intermediaries to focus on their interventions in the innovation system, rather than study their organisational structuring and definition. This somewhat functionalist take on the literature is further inspired by a growing need for clarity amongst the practitioner stakeholders, whose diverse organisational backgrounds nonetheless converge in the questions of – what should we do to achieve a certain result in a given context (Dalziel, 2010; Hargreaves *et al.*, 2012; Klewitz, Zeyen and Hansen, 2013; Agogué *et al.*, 2017)? Furthermore, the scattered literature across this field is exposing another struggle – to consistently define the role(s) intermediaries play in these systems. These roles and functions are well established when it comes to the "brokerage" model, but they break down when a broader systemic view is taken. This leaves a significant amount of studies unaccounted for in innovation intermediaries literature reviews and hence, out of touch with the theoretical (and consequently also operational) developments.

Hence, the conceptualisation I am proposing is grounded on an "intervention", which is defined as any activity intended to bring about a change in the operation of a social system. This very broad definition has origins in public policy literature, though has been used in the innovation domain as well (Chaminade and Esquist, 2006; Hanley, Liu and Vaona, 2015; Mgumia, Mattee and Kundi, 2015; Wang, 2018). Crucially, it encompasses many different types of interventions from broader framework development, such as economic incentives or legal changes, to direct activities carried out with multiple parties or participants.

Interventions are (or should be) underpinned by a clear theory of change (Brousselle and Champagne, 2011; Clark and Taplin, 2012; Jackson, 2013). Theories of change provide justification for interventions and use logic modelling or other tools to map the proposed action against expected outcomes – a cornerstone of innovation policy (Autio, Kanninen and Gustafsson, 2008; Russo and Rossi, 2009; Edler *et al.*, 2013). It is important to note that any realistic interventions can rarely be the sole cause of a particular outcome, rather they contribute to it, as can be examined by contribution analysis (Brousselle and Champagne, 2011). Hence, a theory of change is premised on the causal attribution reasoning, which defines a contribution of the intervention towards the desired effect: good theories of change have clearly identified (pre-)conditions, rationales for available intervention(s) and measurable indicators linked to specific outcomes or impacts (Clark and Taplin, 2012). Each particular intervention requires a bespoke instance of a theory of change proposition, responding to the existing circumstances within which the intervention will be deployed, though the theory's elements (i.e. known tools to achieve a certain goal) can be adopted from a generic pool.

I argue, that this broader framing successfully includes all deployments of activities and resources put forward by innovation intermediaries. The reasoning (i.e. the theory of change) behind their interventions is the intention to change the innovation landscape on macro-, meso- or micro- level, as well as deliver specific economic, political and social outcomes. On one hand, such mandate for, and investment in, change is based on the available financial and social capital. On the other hand, the intervention's objectives depend on the analysis of the existing context or environment and the available theoretical and empirical understanding of possible and available interventions, though this often includes political/ideological considerations and not merely evidence (Howells, 2006).

Hence, a successful intervention-setting requires an in-depth analysis of the contextual environment followed by a (transparent) decision-making on the appropriateness of a specific intervention given the available understanding. However, the latter is sorely lacking, in particular, as noted by Hannon, Skea and Rhodes (2014) referring to further evidence from several studies:

> *"[…] the literature is currently too fragmented (Howells, 2006, Van der Meulen et al., 2005) […]" and "we possess only a limited 'understanding of these entities, their role, their functions, and their activities in different contexts' (Abbate et al., 2013 p.235)" (Hannon et al., 2014:8).*

In particular, as dynamic and pro-active organisations, innovation intermediaries are often closely aligned to other aspects of public life, especially politics and economy, and their stability and endurance in a great part depend on their ability to adapt and morph with time (Howells, 2006). This is underpinned by processes of social learning (Hyysalo and Stewart, 2008; Ngwenya and Hagmann, 2011). Hence, I argue an evidence-based systematisation of the intermediaries' interventions is needed in order to enable both the advancement of our theoretical and empirical understanding of intermediaries and their interventions as well as assisting in the operational deployment of the current literature.

Building on Past Attempts to Systematise Intermediaries Interventions

Several attempts have been made by different authors to classify the various intermediaries' interventions into organised groups, related by activity, intent/objectives or other parameters (Howells, 2006; Dalziel, 2010; Kilelu *et al.*, 2011; Nilsson and Sia-Ljungström, 2013; Kivimaa, 2014; Kim, 2015; Lukkarinen *et al.*, 2018). For example, when looking at innovation intermediaries interventions, Dalziel identifies three key areas of activity for intermediaries (Dalziel, 2010):

- Inter-organizational networking activities;
- Technology development (and related activities); and
- Other activities.[19]

However, this classification seems incomplete in the range of interventions included as well as overly simplistic in terms of categorisation. While their analysis is helpful in terms of providing a concrete programmatic analysis of what intermediaries (can) do to "fix the innovation gap", their focus on networking is detracting from other modes of engagement intermediaries' undertake, in particular in wider socio-political engagement.

In a more complete manner, Howells' (2006) lists the following "typology of intermediation in innovation process":

1. Foresight and Diagnosis
2. Scanning and Information processing
3. Knowledge Processing, Generation and Combination
4. Gatekeeping and Brokering
5. Testing, Validation and Training
6. Accreditation and Standards
7. Regulation and Arbitration
8. Intellectual property: protecting the results
9. Commercialisation: exploiting the outcomes

[19] This last category is labelled here as "Business Development Provision", as the interventions listed in this group are mainly concerning the running of the business operation and human resources development. See Annex 1 for full classification.

10. Assessment and Evaluation

Conversely, the above list is less of classification and more of a list of functions, and even as such its complexity does not positively contribute to the deficit of theoretical and operational clarity described earlier. Hence, starting from Howells (2006) and expanding on it, Lopez-Vega identified three categories of intermediaries “functions” (Lopez-Vega, 2009):

- functions which facilitate the collaboration between organizations;
- functions which involve connecting services between an organization and its environment; and
- functions which provide various services to stakeholders.

However, the extensive focus on “knowledge brokerage” and “social learning”, further limits this analysis to social activities and “soft capital” (i.e. knowledge, information, know-how, status, contacts, etc.). Dalziel’s analysis, for instance, also includes the provision of physical space and equipment as a very significant type of intervention (Dalziel, 2010). In a similar manner Kilelu, et al. conclude that

“Following a comprehensive review of various authors who have looked at roles and functions of intermediaries and brokers in supporting and managing innovation processes (van Lente et al., 2003; Smits and Kuhlmann, 2004; Howells, 2006; Klerkx and Leeuwis, 2008b; Kristjanson et al., 2009), we noted six broad functions, namely:

- Demand articulation/stimulation
- Network brokering
- Knowledge brokering
- Innovation process management
- Capacity building
- Institutional building” (Kilelu *et al.*, 2011, p. 13)

Kilelu et al. classification is far more promising than the ones suggested earlier, as the systemic “functions” listed here (see Annex 1 for a schematic representation) are clearly linked to a proposed four-dimensional intermediaries’ typology (Kilelu *et al.*, 2011), with Systemic Brokers, Technology Brokers, Enterprise Development Support and Input Access-

Focused Intermediaries identified as the four distinct types.[20] However, I maintain that the issue with these two approaches is that they link interventions (functions) with organisational dynamics, instead of producing a typology of interventions themselves, which can be deployed independently of each other responding to a wider systemic dynamics and simultaneously perform different roles and functions.

Furthermore, as these attempts often start with Howells (2006) classification, the analyses frequently do not include some of the available interventions, in particular, provision of physical space and equipment. This latter issue can be found in Kivimaa typology as well (shown in Annex 1), though it otherwise does helpfully link functions with four groups/classes of interventions - i.e. Articulation of expectations and visions, Building of social networks, Learning processes and exploration at multiple dimensions and Other (Kivimaa, 2014). However, I have also noted that this typology is also cumbersome to implement, as its systematisation does not propose any substantive sub-divisions of interventions, leaving a plethora of examples from past studies un-harmonised.

Deploying a different approach, starting from the innovation systems features and attempting to fit intermediaries' activities to them, Nilsson and Sia-Ljungström (2013) highlight that:

> *"Bergek et al. and Hekkert et al. provide inventories of system functions, including: Knowledge development and diffusion; Entrepreneurial experimentation; System infrastructure creation; Influence on the direction of search; Market formation; Legitimation; Resource mobilization; and Development of positive externalities/synergies."*
> (Nilsson and Sia-Ljungström, 2013, p. 163)

Their subsequent analysis of intermediaries' operations based on these pre-identified "system functions" provides a more board insight into the variety of available interventions,

---

[20] There is a similar typology derived empirically by (Colombo, Dell'Era and Frattini, 2015), who define four intermediary types as Connector (gather information regarding the experience and competences), Broker (identify the sources of knowledge), Collector (provide solutions) and Mediator (establish a relationship). Another such typology is forwarded by Kim (2015) who describes four overarching "roles" as: Knowledge enabling, Facilitating relations, Facilitating learning, Managing interfaces.

though they note the slight disconnect between the operational activities the intermediaries deploy and the more abstract system features. They specifically comment on

> *"[…] the need for further work on understanding not only to the extent these innovation system functions are fulfilled by innovation intermediaries but also the magnitude, the type of interaction and the indirect effects these activities can have on the innovation system."*
> (Nilsson and Sia-Ljungström, 2013, pp. 171–172)

Hence, my approach is to develop further understanding of innovation intermediation marks a clear attempt to transcend the three identified issues:

- the incompleteness of analysed array of interventions
- lack of clarity in classification
- lack of links between available interventions and their systemic functions

I argue that the key analytical tool needed for developing an improved advanced systematisation is a functional classification system, expanding on the ones presented above, which would encompass all available interventions, yet retain theoretical and operational clarity. In order to embed such clarity of function in the classification, the latter has to be linked to a true framework of the established classes of interventions, which takes into consideration practitioners concerns and their policy requirements as well as operational constraints (Klewitz, Zeyen and Hansen, 2013). These may relate to scale and intensity of engagement within a given intervention, the two being in approximate inverse correlation, or ability to deploy particular types of resources and activities[21].

Taking the literature reviews outlined above as a starting point, this paper exposes their divisions, in particular examining how the dividing lines between key studies and approaches are drawn. This is achieved by analysing the key areas of overlap and distinction amongst seven systemic reviews in particular (Howells, 2006; Dalziel, 2010; Kilelu *et al.*, 2011; Nilsson and Sia-Ljungström, 2013; Kivimaa, 2014; Kim, 2015; Lukkarinen *et al.*, 2018) as well as in incorporating additional studies. Tentative reasoning behind those dividing lines is established by critical analysis of the studies cited within the reviews, which are then also

---

[21] A more complete typology emerging from this classification framework is also being derived from these considerations, and additional empirical work, and will be presented elsewhere.

retrofitted with the newly proposed classification framework, in order to test and validate the model, pending further empirical validation.

Discussion: A New Interventions' Classification

When analysing the review of innovation intermediation literature and in particular when contrasting the somewhat one-sided classifications as I described in the previous section, a key set of dividing lines between the studies has emerged. These key differences were exposed as:

- Dalziel is the only study to include specific references to physical space and equipment provision (Dalziel, 2010), though Nilsson and Sia-Ljungström (2013) mention broader "physical infrastructure". This is linked to the broader definition of intermediation and the role of support activities (related to cited studies of substantial infrastructural investment) being included in their analysis as a move beyond the "brokerage function".
- This led to an additional review of incubation studies (Hackett and Dilts, 2004), which exposed a significant emphasis on infrastructural set-up and related financial investment within that segment of the literature, which is otherwise not present. This was further linked to the analysis of political mandate and neutrality, as seen in Kivimaa (2014) and Klerkx and Leeuwis (2008), related to sectoral emergence/transitioning and stabilisation/maturity.
- Lukkarinen et al. (2018) are the only ones exclusively focusing on "soft" / relational interventions, though most of the studies are heavily concentrated around "brokerage" function of intermediaries (Howells, 2006; Kim, 2015). Such concentration is exposing the interest as well as a contextual focus for these types of interventions. In particular, many studies cited describe lower levels of investment, yet more specific targeted outcomes. These interventions are predominately run by public bodies or trade organisations.
- Many studies allude to direct work done in the innovation process and/or its management (Kim, 2015), some also note the deployment of (soft) capital (Kilelu *et al.*, 2011; Lukkarinen *et al.*, 2018). Examining cited sources shows that these more hands-on types of interventions seem related to early stages of sectoral development (Kivimaa, 2014).

- Additional studies reinforce the point above, as there is a significant concentration of studies depicting high-level of intermediaries' involvement in early stages of sectoral developments (Antikaninen, Mäkipää and Ahonen, 2009; Agogué, Ystrom and Le Masson, 2013; Katzy *et al.*, 2013), which are missing from those analysis of more systemic activities (Vonortas, 2002; Boon *et al.*, 2011) in more mature sectors.

From the above observations, the following three key dividing lines were established between:

- high levels of investment in resources vs active enactment of a strong vision/political mandate; the larger the amount of investment, the more the intermediaries have to be careful to appear neutral as to the vision for the sector and vice-versa;
- specific and targeted hands-on involvement in supporting business or product development vs bigger (more hands-off) systemic support; there is also a significant correlation tentatively noted between these two types of engagement and sector's growth and maturity; and
- interventions which are inherently physical, i.e. provision of space and equipment, holding meetings, doing work, vs those which are social in character, i.e. development of knowledge and skills, translation of interests, deployment of capital; though it is often the case that the "physical" interventions are pre-cursors or enablers of the "social" ones.

Building on these observations, I propose that the available interventions can be classified using a comprehensive classification, presented in the framework below (Table 8), which is devised to include most available interventions, as analysed in a detailed review of academic literature discussed previously. A detailed analysis of the classification units is presented in the next section.

I constructed the classification using two overarching categories of interventions, resources provision and deployment of activities, as related to the varying focus of interventions from more broad and systemic (such as investments in resources) to more targeted and specific (such as direct activities to shape a particular vision for development). This was derived from the first dividing line finding listed above and seen by a clear lack of analysis in some parts of intermediation literature (Howells, 2006; Kilelu *et al.*, 2011; Kivimaa, 2014; Lukkarinen *et al.*, 2018), which focused predominantly on active engagement with the sector, but somewhat neglected resources provision analysis. It also echoes to a degree the “proactive, reactive, and passive approaches” to intermediation identified by Lichtenthaler (2013).

These categories are then split into subcategories of infrastructure, tools, framing and project, with dividing those with more hands-on types of interventions (such as engaging in projects and developing infrastructure) to those delivered in more hands-off roles (such as sector framing and providing tools for innovation). This is related to the second dividing line established above, specifically noted in the examination of additional sources beyond the four key literature reviews. On the subcategories level, the classification is further split by intervention qualifiers of being either more “physical” or more “social” in character (first finding). These overarching qualifiers enable the intermediaries to distinguish between deployment of “hard” and “soft” assets, such as buildings and equipment on one hand, and social capital and thought leadership on the other.

This classification has been retrofitted to all systemic literature reviews listed earlier as well as additional literature analysis, as can be seen in Annex 2. The results show clearly that several of the dividing lines established above can be easily identified in this model, as classification tables have a high concentration in the areas of overlap of interest (translation function in particular). It is also clear that all studied interventions fit within the framework (all functions can be classified).

Detailed Analysis of Intervention’s Classifications

Taking each of the categories and classes, in turn, this section and the corresponding Table 8 outlines the key analytical work behind framing the resulting classification out of understanding each of the literature’s dividing lines, looking beyond the discussed systemic reviews and into their source material. The resulting analysis is also exposing additional depth to the modalities of delivering the different classes of interventions, suggesting the categories and qualifiers emerging from the dividing lines can be understood in the context of key parameters for operational deployment. In particular, the categorisation and qualification of the various available classes of interventions correspond to the level of the development of the sector and individual actors as well as demonstrate its dependency levels of investment and involvement, strength of vision/mandate and soft leadership embedded in the intermediaries’ programmes, which will be outlined in more detail in the next section.

Resources

The resources category is the overarching descriptor for the provision of physical and social infrastructure, such as physical spaces, knowledge (networks), equipment and skills, as needed by the actors in the innovation system. These are often related to significant financial investment and conversely not to a strong vision for the specific technology development focus, in particular, if the funding is from public sources (Hinloopen, 2004; Klerkx and Leeuwis, 2008). They are divided into two sub-categories, infrastructure and tools, to account for the intensity of (hands-on) involvement, which is more significant when infrastructure is being developed and deployed than when tools are provided.

Infrastructure

The systemic provision of infrastructure, such as innovation-supporting physical and social environment/space is seen as a critical targeted intervention aimed at providing the broad-base resources for enterprise formation and development. These resources are most often provided at scale and hence require significant upfront investment (Hackett and Dilts, 2004), as well as an extensive close-up management effort to ensure smooth running and development (Kivimaa, 2014).

Space

Physical infrastructure in the broadest sense denotes all elements of the built environment needed for hosting business. The most common example is the provision of office space and other facilities, such as Internet access (Markides and Anderson, 2006). This is often done via the establishment of incubation facilities for start-ups and spin-outs/-offs (Hackett and Dilts, 2004) or managed shared office rentals for larger firms (Phan, Siegel and Wright, 2005). These resources often include as vital features (shared) meeting rooms, social spaces and a bespoke postal address.

Knowledge

Knowledge understood as an enabling factor for innovative enterprise and interventions of this type are targeted at providing or increasing access to knowledge and information, in order to create successful businesses (Klerkx and Leeuwis, 2008; Abbate, Coppolino and Schiavone, 2013; Agogué, Ystrom and Le Masson, 2013). Common examples of specific interventions are the creation and dissemination of knowledge and knowledge management (IP support, networking, etc.).

Tools

In contrast to infrastructural provision, the interventions in the "tools" category can be provided with a less significant commitment to the specific users from the innovation intermediaries (Kivimaa, 2014). They can be deployed in a much more mobile manner and can reach a far larger number of target recipients. However, through the selection of the equipment and skills provided, the intermediaries can exert a certain degree of influence over the dominant innovation trajectories within the system they serve.

Equipment

Provision of specialist equipment is enabling early-stage firms to innovate and demonstrate the soundness of their innovations (Grindley, Mowery and Silverman, 1994; McEvily and Zaheer, 1999; Howells, 2006). This is particularly pertinent in the high-tech sectors, with the need for expensive development tools and high levels of quality assurance (QA). As such, intermediaries can support both NPD and QA processes by providing such equipment, which is often prohibitively expensive and of limited return for value for smaller firms. Examples include rentable laboratory space and equipment, qualification equipment or services, or software or hardware packages.

Skills

In the process of NPD often skills are called for, which are not available within a (small) development team of an SME. Hence, contracted consultative support is required, which is often provided by or made available through intermediary organisations. In particular, intermediaries often support skills matching through formal and informal directories and linkages and offer their own skills to companies, particularly in non-product-specific areas such as business development (Mian, 1996; Vonortas, 2002).

Activities

In the activities category fall all those interventions which are predominantly centred around intermediaries pro-actively trying to shape the direction of the economic area they are engaging with, in particular, organising and leading on interaction amongst the players, translating interests across different stakeholders, deploying capital to specific projects and carrying out work within the innovation process. They are further split by two subcategories, framing and project, which similarly to resources category above, denote the level of involvement by an intermediary, from intense engagement (seen in project-type interventions, often related to emerging sectors) to more hands-off systemic work (in framing-type interventions).

Framing

Framing activities group together interventions which relate to a more systemic leadership role in facilitating interaction and proposing specific visions for future innovation development. They are, hence, linked to stronger intermediation mandates and depend on the deployment of the intermediaries' "soft power", extensively analysed in the literature through the concept of "brokerage" (Howells, 2006; Klewitz, Zeyen and Hansen, 2013).

Interaction

A key enabling activity assisting the development of an innovation-rich environment is inter- and intra- sectoral networking (Kilelu *et al.*, 2011; Kivimaa, 2014). These interactions take place in meetings, events or through either formal or informal processes of matching, pairing and exchange of ideas. Specifically, intermediaries are often involved in the organisation and/or delivery of conferences, symposia, industry meetings, social events, etc. Through digital communication and social media, some of this interaction is now often facilitated online (Randhawa *et al.*, 2017).

Translation

An important role some innovation intermediaries play is centred on activities aimed at the development of the sector's landscape or framework and brand (Human and Provan, 2000; Sapsed, Grantham and De Fillippi, 2007). This in particular related to the promotion of the sector to various internal and external stakeholders, scoping and surveying the state of the actors within the targeted industry, establishment and monitoring of standards and harmonisations, and production of literature and other material to describe, analyse and promote specific or general innovation opportunities and/or outcomes.

Project

Project-based interventions relate to the specific deployment of activities, which utilise innovation intermediaries' capabilities and resources to further targeted innovation journey (Kilelu *et al.*, 2011; Katzy *et al.*, 2013). As such, this "winner picking" approach is related to both a very hands-on involvement, as well as a strong intermediation mandate, since significant gains can be made by the participating actors (Klerkx and Leeuwis, 2008).

Work

Hands-on involvement in project management or delivery is a type of intervention, which is predominantly deployed in early-stage companies or new joint venture enterprises, where active participation of an intermediary allows for specific (challenging) NPD work or harmonisation of interests of several actors (Mazzoleni and Nelson, 2007; Kivimaa, 2014; Klerkx, Álvarez and Campusano, 2015). These can be formal or informal engagements, crucially with a specific targeted outcome and often anticipated impacts or added value beyond the scope of the project itself.

Capital

This sub-category groups interventions linked to more hands-off involvement with specific firms and projects is the investment of capital, which might be financial, in-kind support, or even social capital, such as certification or promotion (Antikaninen, Mäkipää and Ahonen, 2009). Such investments are often made without specific returns in mind, often though competition or tendering set-ups, though some are run on a more commercial basis (Mgumia, Mattee and Kundi, 2015).

	RESOURCES provision of infrastructure and tools for the use of innovation stakeholders		ACTIVITIES active engagement in defining and developing future innovation products	
	INFRASTRUCTURE provision of system-level resources	**TOOLS** provision of specific deployable resources	**FRAMING** activities deployed to facilitate wider system development	**PROJECT** specific innovation projects to interlink stakeholders and further specific innovation pathways
Physical	**space** networked provision of physical space for use by stakeholders *i.e. hireable offices at the intermediary-run facilities; hireable rooms for events*	**equipment** provision of specialist or otherwise inaccessible tools and devices *i.e. hireable facilities; development of new R&D and qualification environments*	**interaction** active development of opportunities for engagement of stakeholders *i.e. organisation of, and attendance at, conferences; events; workshop; fora*	**work** active engagement with innovation projects and investment of staff effort *i.e. work on R&D and commercialisation projects; innovation process management*
Social	**knowledge** systemic provision knowledge (IP) for deployment in innovation processes *i.e. IP/knowledge generation and distribution; knowledge mapping and database*	**skills** provision of expertise, advice and workforce *i.e. hireable expertise; formal training; informal experiences; outreach amongst potential recruits*	**translation** active brokerage between stakeholders and identifying development trends *i.e. involvement in, and leadership of, the development of policy (reports), standards; sector promotion to stakeholders, other sectors and the wider public*	**capital** active deployment of resources (financial or otherwise) to an innovation project *i.e. mobilizing soft and hard capital for R&D and commercialisation projects*

Table 8 - Comprehensive classification of intermediaries' interventions based on literature analysis. Categories are split into subcategories and subcategories are further split by qualifiers as described in "Interventions Classification" section. For a more detailed analysis of categories' definitions see subsection "Detailed Analysis of Intervention's Classifications"; for examples source material see Annex 2

Towards a Typological Model

As referenced throughout the above analysis, mapping out the contextual framing of this classification leads to the identification of four key factors to the presented dividing lines, namely: having a close “hands-on” involvement in the innovation, providing large systemic (financial) investment, exercising soft leadership and enacting a strong vision/mandate. Though not entirely mutually exclusive, these factors seem to establish overall trends in intermediaries engagement with the innovation system, which can be linked to some of the literature fragmentation due to the competing emergent roles and functions.

In the proposed classification, these four factors span across a multitude of classes and categories, establishing a loose coupling of the innovation intermediaries positions within any studied sector and the interventions deployed. The resulting typological framing is best visually represented as a concentric continuum in a four-cornered/diamond scheme (see Figure 12), with high levels of involvement on the bottom, high investment on the left, significant mandate commitment on the opposite side and a soft leadership approach on the top. Furthermore, the social types of interventions are deliberately embedded within a wider frame of physical ones, as the latter is often the enabling factor for the former, as referenced in the third dividing line established previously.

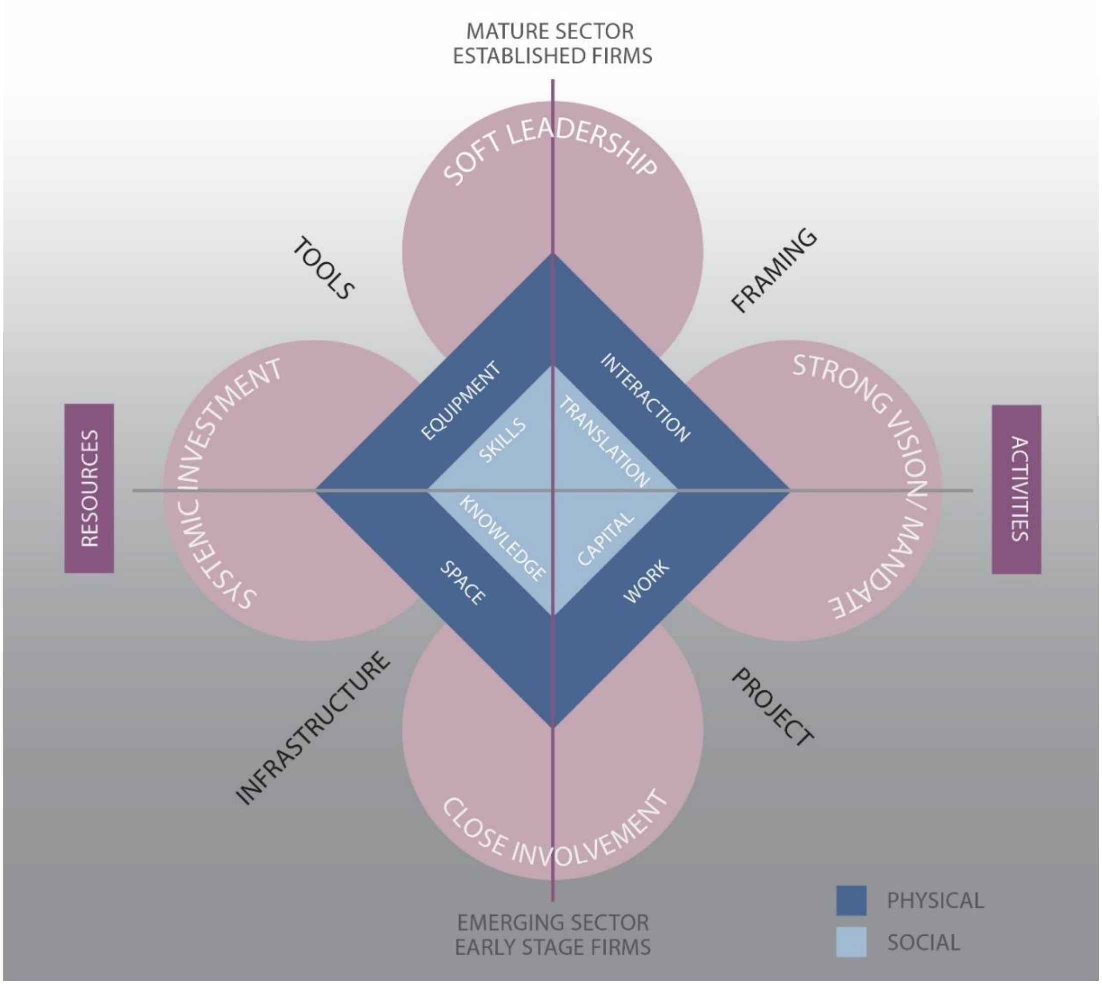


Figure 12 - Innovation intermediaries' interventions proto-typology scheme. The central diamond is formed of intermediaries classification categories, with systemic factors related to these categories indicated in circles underneath. Schematically, the resources vs activities division runs left to right, whilst emergence to maturity development stretched from bottom to the top.

Additionally, as noted by the lower half of the scheme on Figure 12 represents interventions predominantly targeted at emerging sectors and early-stage enterprises, whilst in the top half are interventions the need for which continues to persist even in more mature sectors and established companies. Such view enables both practitioners as well as analysis to trace the evolution on the intermediary as well as the sector it is serving, from an early emerging phase of strong involvement, investment and mutual co-shaping, through to consolidation, maturity and stabilisation.

Tipping the balance to one or the other corner of the typological framing will be related to where the primary focus of an individual intermediary's intervention programme(s) is. The division lines are further illustrated with the engagement types bubbles (in pink), showing the type of intermediaries' agenda/mandate/position within the sector as shaped by undertaking specific classes of interventions. In most cases, it will be either on infrastructural investments or specific trendsetting and project work (most usually associated with early stages of an emerging sector/technology) or on more hands-off activities such as providing spaces and incentives for defining of trends and easing key skills and equipment shortages (associated with development of commercialisation pathways and R&D consolidation of a later stages of development). However, in order to fully develop this proto-typology, further analysis of the deployment of the intervention classes is needed, to deepen the link between the contextual factors presented and the intentions of the interventions deployed.

Conclusions and Future Work

The analysis presented in this paper examined the current state of the art in the innovation intermediaries literature and proposed a three-way fix for some of its most persistent challenges in conceptual and operational reach.

Firstly, I observed that the specific focusing on functional distinctions in the analysis of innovation intermediaries cause most problems. Hence, an augmented pragmatic definition was adopted. As noted by many other authors and practitioners (policymakers and managers), the functional fragmentation and disconnectedness of the theoretical framework are of theoretical and practical concern. In particular, it stands in the way of establishing the analysis of best practice in innovation intermediation, as well as leaves intermediaries without a coherent perspective on types of available tools.

Secondly, through a systematic literature review of the recent empirical work in innovation intermediation, I noted the tendency amongst researchers to frame their work in a geographically and sectoral bounded cases. Linking these to the Geographically-bound Sectoral System of Innovation (GSSI), I proposed such framing as the de facto analytical unit for comprehensive analysis of innovation intermediation.

Thirdly, to address the issues above, I shifted the focus from intermediaries as organisations towards their interventions as the main objective of the study. This is a key change of perspective, enabling a closer link between analytical systematisation of innovation intermediaries roles and functions to their operational planning and deployment. Examining existing literature in this area shows significant gaps and division lines, which are in turn exposing the diversity and complexity of innovation intermediaries operations, which are seldom addressed comprehensively and lack an overall unifying framework.

Finally, using these gaps and divisions, this study proposed a comprehensive and inclusive classification framework based on analytically derived distinctions between interventions based on provision of resources (such as infrastructure and tools) vs. deployment of activities (through framing and projects) and further qualified sub-categorisations of infrastructure, knowledge, tools and skills provision and activities to enable interaction, translation project work and capital. This enables theoreticians and practitioners alike to identify the systemic role of a particular intervention as well as identify a specific type of intervention in order to fulfil systemic requirements. Looking back at the analysis of previous studies, the framework was successfully retrofitted to an array of past innovations intermediaries' literature.

Current limitations of this work relate in particular to the inherent difficulty of harmonising the myriad of different frameworks, which inevitably leads to certain generalisations and omission, and lack of empirical deployment. However, this framework is being tested empirically with a detailed analytical case study of key intermediaries' interventions in an emerging regionally-bound sectoral innovation system, the (New) Space Sector in Scotland, including further typological analysis of the classes of interventions. Additional studies are also being proposed, such as within examining nationally-bound trans-sectoral systems, such as the Catapults network in the UK (following Kerry & Danson, 2016). I hope that more studies deploying this classification framework become available in the near future as well as is looking forward to constructive criticism and feedback of this classification model.

Annex 1: Previous Classifications

Howells (2006)

Table 3
Typology of intermediation in the innovation process

Type	Function	Comments	Example of organization providing the function
1. Foresight and diagnostics			
(a) Technology foresight and forecasting	Foresight, forecasting and technology roadmapping		CERAM, Oakland, PERA, SIRA
(b) Articulation of needs and requirements			Oakland, PERA, SIRA
2. Scanning and information processing			
(a) Scanning and technology intelligence	Information scanning and technology intelligence	Information gathering and identification of potential collaborative partners	PERA, Oakland, CERAM
(b) Scoping and filtering	Selection and clearing function	Selection of collaborative partners	PERA, Oakland
3. Knowledge processing, generation and combination			
(a) Combinatorial	Helping to combine knowledge of two or more partners		AMTRI, BSI, CERAM, DsX, LCG Bioscience, LGC, MERL, NEL, PA Group, PERA, Roke Manor Research, Scientific Generics, Scipher, SIRA, TTP, UrbiNetics
(b) Generation and recombination	As (a) above, but also generating in-house research and technical knowledge to combine with partner knowledge		AMTRI, BSI, CERAM, DsX, LCG Bioscience, LGC, MERL, NEL, PA Group, PERA, Roke Manor Research, Scientific Generics, Scipher, SIRA, TTP, TTP Communications, UrbiNetics
4. Gatekeeping and brokering			
(a) Matchmaking and brokering	Negotiation and deal making	Facilitating contract negotiation once partner(s) selected	Generics, TTP
(b) Contractual advice	Finalising the contract	May involve specialist IP expertise (see 8)	Generics, QED, UMIP
5. Testing, validation and training			
(a) Testing, diagnostics, analysis and inspection		Test chambers and laboratories	7Layers UK, AMTRI, BSI, CCFRA, MERL, LCG Bioscience, LGC, Premier Research, UrbiNetics
(b) Prototyping and pilot facilities			AMTRI, CERAM, Roke Manor Research
(c) Scale-up		Including manufacturing modelling to overcome bottlenecks	CERAM, Roke Manor Research
(d) Validation		Validation of analytic methods	BSI, CCFRA, LGC, NEL
(e) Training		Joint training in use of new technologies	CCFRA, PERA, SIRA
6. Accreditation and standards			
(a)	Specification setter or providing standards advice	Includes developing reference designs	BSI, NEL, PERA, UbiNetics
(b)	Formal standards setting and verification		BSI, NEL
(c)	Voluntary and de facto standards setter		BSI, NEL, CERAM
7. Regulation and arbitration			
(a) Regulation		Formal regulation	–
(b) Self-regulation		Quasi-formal basis as an agency involved in self-regulation	–
(c) Informal regulation and arbitration		Informal arbiter between different groups, for example, between consumers and producers	BSI
8. Intellectual property: protecting the results			
(a) Intellectual property (IP) rights advice	Protecting the outcomes of collaboration	Help clients assess their ideas for IP protection	QED IP Services, Generics Asset Management
(b) IP management for clients		Securing IP rights and their management	QED IP Services, Generics Asset Management
9. Commercialisation: exploiting the outcomes			
(a) Marketing, support and planning	Market research and business planning	Identify market opportunities and develop business plans	Generics Asset Management
(b) Sales network and selling	Support in the selling and commercialisation process	Help establish and run sales channels	–
(c) Finding potential capital funding and organising funding or offerings	Early stage capital	Assessment and filtering capability for funding – 'proof of principle' funding	E-Synergy, Generics Asset Management, UMIP
(d)	Venture capital	'Follow on' funding	UMIP
(e)	Initial Public Offering		Generics Asset Management
10. Assessment and evaluation			
(a) Technology assessment		General assessment of performance and technologies (see 1)	CERAM, Oakland, PERA
(b) Technology evaluation		Specific evaluation of products and technologies once in the market (see 1)	–

Dalziel (2010) Literature review and Classification (adapted into a table)

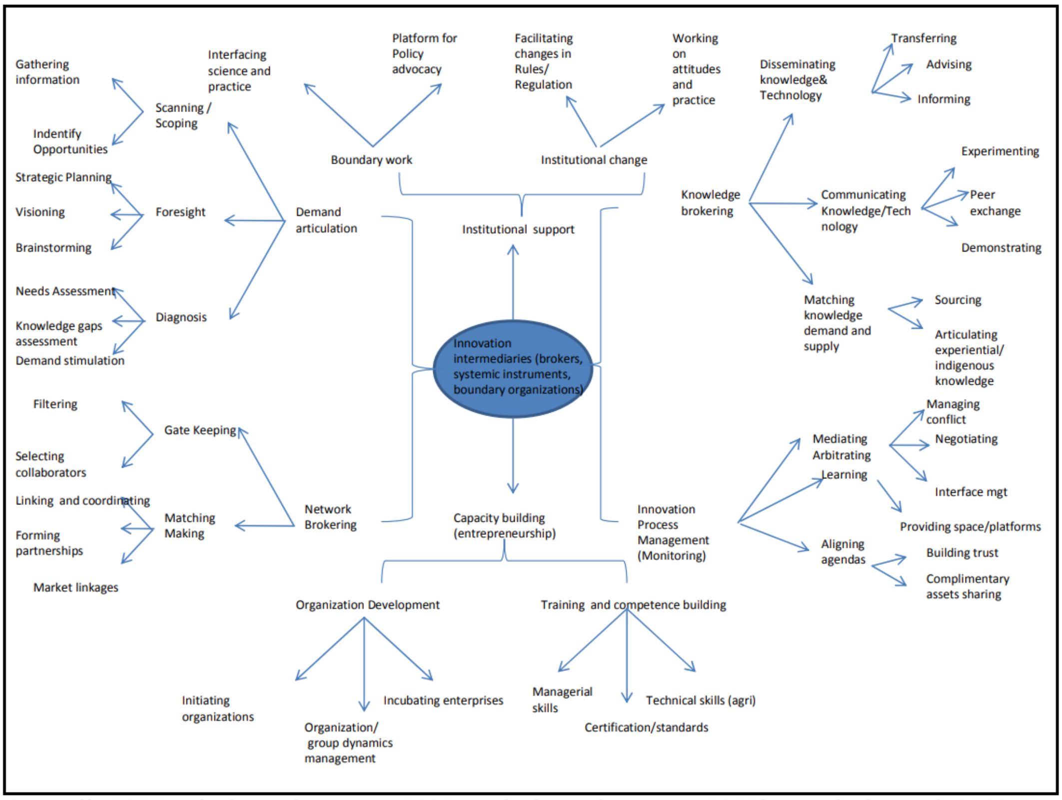
Inter-organizational networking activities			Technology development and related activities	Business Development provision
Provision of information or advice	Facilitation of promotion or influence	Networking activities		
scanning and information processing (Howells, 2006)	cluster promotion (Sapsed, Grantham and De Fillippi, 2007)	helping to combine the knowledge or experience of two or more partners, brokering, and standards development (Grindley, Mowery and Silverman, 1994; Bessant and Rush, 1995; Howells, 2006)	access to expertise and equipment (Mian, 1996; Howells, 2006)	physical space (Löfsten and Lindelöf, 2002; Phan, Siegel and Wright, 2005)
transferring specialized knowledge (Bessant and Rush, 1995)	industry promotion (Human and Provan, 2000)		standards development and support for systems development (Grindley, Mowery and Silverman, 1994; Fuchs, 2009)	training activities (Mian, 1996; McEvily and Zaheer, 1999)
diffusing information and best practise techniques (Grindley, Mowery and Silverman, 1994)	helping users articulate innovation needs (Bessant and Rush, 1995)		testing and validation of new technologies and equipment (Grindley, Mowery and Silverman, 1994; McEvily and Zaheer, 1999)	advice related to sales and marketing activities (Bessant and Rush, 1995; Howells, 2006)
			adapting technologies for alternate applications (Bessant and Rush, 1995; Mazzoleni and Nelson, 2007)	
			intellectual property management and other related activities (Siegel, Waldman and Link, 2003; Markman *et al.*, 2005)	

Kivimaa (2014) Classification Based on a Literature Review

Table 2. A typology of intermediary roles as contributors to niche internal processes.

Articulation of expectations and visions	Building of social networks	Learning processes and exploration at multiple dimensions	Other
• Articulation of needs, expectations and requirements (A1)[1,2,3,4,5] • Strategy development (A2)[2,5] • Acceleration of the application and commercialisation of new technologies (A3)[1,2,6] • Advancement of sustainability aims (A4)[6,7]	• Creation and facilitation of new networks (N1)[1,4,5,6,8,9] • Gatekeeping and brokering (N2)[3,4,5,8] • Configuring and aligning interests (N3)[2,4,6,8,9] • Managing financial resources – finding potential funding and funding activities (N4)[1,3,4,6,8] • Identification and management of human resource needs (skills) (N5)[1,2,4,6,8]	• Knowledge gathering, processing, generation and combination (L1)[1,3,6,8] • Technology assessment and evaluation (L2)[3] • Prototyping and piloting (L3)[1,3,6,8] • Investments in new businesses (L4)[1] • Communication and dissemination of knowledge (L5)[1,2,4,6,8] • Education and training (L6)[1,6,8] • Provision of advice and support (L7)[4,5,6] • Creating conditions for learning by doing and using (L8)[2,8,9]	• Arbitration based on neutrality and trust[*] (O1)[3] • (Long-term) project design, management and evaluation (O2)[1,2,3,6,9] • Policy implementation (O3)[3,9] • Accreditation and standard setting (O4)[3,8] • Creating new jobs (O5)[10]

Kilelu et al. (2011) Systematisation of Interventions



Kim (2015) Roles and Activities of Innovation Intermediaries

Table 3-3 Roles and Activities of Innovation Intermediaries in the NIS

Roles	Activities	Supporting literature
Knowledge enabling	Demand articulation Knowledge generation and combination configuration Customising knowledge to a specific context	Boon et al. (2008), Brown and Duguid (1991), Clarke and Ramirez (2011), Howells (2006), Smits and Kuhlmann (2004)
Facilitating relations	Bridging links and aligning actors Facilitating interpersonal communications and relationships Building trust	Howells (2006), Klerkx and Leeuwis (2008), Moss et al. (2009), Smits and Kuhlmann (2004), Van Lente et al. (2003)
Facilitating learning	Stimulating interaction and enhancing mutual adaptation Building new routines and skills through interaction (feedback mechanism)	Backhaus (2010), Boon et al. (2008), Smits and Kuhlmann (2004), Stewart and Hyysalo (2008), Van Lente et al. (2003)
Managing interfaces	Providing facilities and other knowledge infrastructures Providing access to human resources	Clarke and Ramirez (2011), Hargadon and Sutton (1997), Howells (2006), Van Lente et al. (2003)

Nilsson and Sia-Ljungström (2013) Innovation Systems Functions

Table 1. Functions of technological innovation systems (adapted based on Bergek et al., 2008b; Hekkert et al., 2007)

Innovation system function	Description	Examples of key output
Knowledge development and diffusion	Creation of new knowledge and facilitation of information and knowledge exchange.	Scientific, technological, and market knowledge. Built and disseminated through R&D, learning from new applications, imitation etc.
Entrepreneurship	Creation of new businesses	New businesses and firms
System infrastructure creation	Development and maintenance of the infrastructure of the system	Physical infrastructure, e.g. production plants, laboratories and roads. Non-physical infrastructure, e.g. research groups, innovation intermediaries, and educational institutes.
Resource mobilization	Building and attraction of resources (human, financial, complementary etc.) relevant to the RIS.	Labour markets (skilled people); financial capital (e.g. venture capital); complementary assets (e.g. support services and products, input goods)
Legitimation	Creation and building understanding, support and legitimacy for the RIS activities and agendas (internally and externally).	Internally: Strategic coherence, joint vision, shared understanding etc. Externally: Coherent image of the regional industry or agenda towards external actors.
Facilitation/creation of synergies	Identification and utilization of synergies within the system. Indicates the dynamics of the system since externalities magnify the strength of the other functions.	Collaboration and joint projects (e.g. joint product development, processing, R&D, lobbying, resource development etc.)
Guidance of search	Attraction of external actors to the RIS, to direct their search and investments towards the system. Also to direct the attention of actors in the system towards specific problems and growth opportunities.	Attract actors to enter the RIS. Identification of problems and opportunities and guide existing RIS actors' attention to address these.
Market identification and formation	Identification of markets or market niches as well as stimulation of the formation of local markets.	Business opportunities identified and demand stimulated/created.

Annex 2: Reclassification of key literature reviews

Howells (2006)

	RESOURCES		ACTIVITIES	
	INFRASTRUCTURE	TOOLS	FRAMING	PROJECT
Physical	**space**	**equipment** Testing, Validation and Training*	**interaction** Gatekeeping and Brokering	**work** Commercialisation: exploiting the outcomes* Intellectual property: protecting the results
Social	**knowledge** Knowledge Processing, Generation and Combination*	**skills** Testing, Validation and Training*	**translation** Foresight and Diagnosis Scanning and Information processing Accreditation and Standards Regulation and Arbitration Assessment and Evaluation Knowledge Processing, Generation and Combination*	**capital** Commercialisation: exploiting the outcomes*

*subdivisions of these types of functions belong to more than one of classification sub-categories

Dalziel (2010)

	RESOURCES		ACTIVITIES	
	INFRASTRUCTURE	TOOLS	FRAMING	PROJECT
Physical	**space** physical space (Löfsten and Lindelöf, 2002; Phan, Siegel and Wright, 2005)	**equipment** access to expertise and equipment (Mian, 1996; Howells, 2006)	**interaction**	**work** adapting technologies for alternate applications (Bessant and Rush, 1995; Mazzoleni and Nelson, 2007) testing and validation of new technologies and equipment (Grindley, Mowery and Silverman, 1994; McEvily and Zaheer, 1999)
Social	**knowledge** helping to combine the knowledge or experience of two or more partners, brokering, and standards development (Grindley, Mowery and Silverman, 1994; Bessant and Rush, 1995; Howells, 2006) intellectual property management and other related activities (Siegel, Waldman and Link, 2003; Markman *et al.*, 2005) transferring specialized knowledge (Bessant and Rush, 1995)	**skills** training activities (Mian, 1996; McEvily and Zaheer, 1999) advice related to sales and marketing activities (Bessant and Rush, 1995; Howells, 2006) diffusing information and best practice techniques (Grindley, Mowery and Silverman, 1994)	**translation** standards development and support for systems development (Grindley, Mowery and Silverman, 1994; Fuchs, 2009) helping users articulate innovation needs (Bessant and Rush, 1995) cluster promotion (Sapsed, Grantham and De Fillippi, 2007) industry promotion (Human and Provan, 2000) scanning and information processing (Howells, 2006)	**capital**

Kivimaa (2014)

	RESOURCES		ACTIVITIES	
	INFRASTRUCTURE	TOOLS	FRAMING	PROJECT
Physical	**space**	**equipment**	**interaction** Creation and facilitation of new networks Gatekeeping and brokering	**work** Acceleration of the application and commercialisation of new technologies Prototyping and piloting (Long-term) project design, management and evaluation Creating new jobs
Social	**knowledge** Knowledge gathering, processing, generation and combination Communication and dissemination of knowledge	**skills** Identification and management of human resource needs (skills) Education and training Provision of advice and support Creating conditions for learning by doing and using	**translation** Articulation of needs, expectations and requirements Advancement of sustainability aims Strategy development Configuring and aligning interests Technology assessment and evaluation Arbitration based on neutrality and trust Policy implementation Accreditation and standard setting	**capital** Managing financial resources – finding potential funding and funding activities Investments in new businesses

Lukkarinen, et al. (2018)

	RESOURCES		ACTIVITIES	
	INFRASTRUCTURE	TOOLS	FRAMING	PROJECT
Physical	**space**	**equipment**	**Interaction'**	**work**
Social	**knowledge** Knowledge development and diffusion	**skills**	**translation** Influence on the direction of the search; Entrepreneurial experimentation; Market formation; Legitimation; Development of positive externalities	**capital** Resource mobilisation

Kilelu et al. (2011)

	RESOURCES		ACTIVITIES	
	INFRASTRUCTURE	TOOLS	FRAMING	PROJECT
Physical	**space**	**equipment**	**interaction** Network brokering	**work** Innovation process management
Social	**knowledge** Knowledge brokering	**skills** Capacity building	**translation** Institutional building Demand articulation	**capital** Demand stimulation

Kim (2015)

	RESOURCES		ACTIVITIES	
	INFRASTRUCTURE	TOOLS	FRAMING	PROJECT
Physical	**space**	**equipment**	**interaction** Facilitating interpersonal communications and relationships	**work**
Social	**knowledge** Knowledge generation and combination configuration Providing facilities and other knowledge infrastructures	**skills** Building new routines and skills through interaction (feedback mechanism) Providing access to human resources	**translation** Demand articulation Customising knowledge to a specific context Bridging links and aligning actors Building trust Stimulating interaction and enhancing mutual adaptation	**capital**

Nilsson and Sia-Ljungström (2013)

	RESOURCES		ACTIVITIES	
	INFRASTRUCTURE	TOOLS	FRAMING	PROJECT
Physical	**space** System infrastructure creation	**equipment**	**interaction**	**work** Entrepreneurship Facilitation/creation of synergies
Social	**knowledge** Knowledge development and diffusion	**skills**	**translation** Guidance of search Market identification and formation Legitimation	**capital** Resource mobilization

Additional studies

	RESOURCES		ACTIVITIES	
	INFRASTRUCTURE	TOOLS	FRAMING	PROJECT
Physical	**space** incubation (Hackett and Dilts, 2004)	**equipment**	**Interaction** 'Network building' (Boon *et al.*, 2011) matchmaking and innovation process design (Katzy *et al.*, 2013) network brokerage (Klewitz, Zeyen and Hansen, 2013) support establishment of business enterprise at R&D institutions (Mgumia, Mattee and Kundi, 2015)	**work** 'Project stimulation' (Boon *et al.*, 2011) management of collaborative projects (Katzy *et al.*, 2013) innovation process management (Klerkx, Álvarez and Campusano, 2015)
Social	**knowledge** architect of collective exploration (Agogué, Ystrom and Le Masson, 2013) establishing institutional infrastructure (Hargreaves *et al.*, 2012)	**skills** effectively managing the firm, and training employees (Vonortas, 2002) aggregating lessons learned (Hargreaves *et al.*, 2012)	**translation** locating and approaching the customer, developing relationships of trust, accessing finance (Vonortas, 2002) 'Management of expectations'; 'Urging for action'; 'Stay on Track'; 'Following others'; 'Active case building'; 'Administrative consultation'; 'Knee–jerk reaction'; 'Testing the waters'; 'Reflection'; 'Unfinished business' (Boon *et al.*, 2011) Demand articulation (Klerkx and Leeuwis, 2008) Framing action and brokering and managing partnerships (Hargreaves *et al.*, 2012) Demonstrate the actual and latent potential of the new technologies (Mgumia, Mattee and Kundi, 2015)	**capital** non-monetary stimulus (Antikaninen, Mäkipää and Ahonen, 2009) project valuation and portfolio management (Katzy *et al.*, 2013) setting-up of innovation-specific business enterprises (Mgumia, Mattee and Kundi, 2015)

Chapter 5: Enablers, Equippers, Shapers and Movers - *A Typology of Innovation Intermediaries Interventions and the Development of an Emergent Innovation System*

Introduction

Innovation intermediaries are seen throughout the innovation studies literature as key players in the development of emerging economic sectors and activities. In particular, intermediaries' knowledge brokerage function has been examined in detail, though many authors agree that the overall understanding of the functions of innovation intermediaries is fragmented and hard to operationalise (Abbate, Coppolino, & Schiavone, 2013; Dalziel, 2010; Hannon, Skea, & Rhodes, 2014; Howells, 2006; Van der Meulen et al., 2005). Building on an extensive literature review, a new classification for analysing these organisations and their roles within geographically-bound sectoral systems of innovation (GSSI) was already developed based on a more inclusive the definition of innovation intermediaries, a shift in focus from "roles" to "interventions", and proposing a new eight-part classification of innovation intermediaries' interventions (Vidmar, 2018). However, to examine the applicability of this emerging classification for addressing the real-life challenges of fragmentation and inoperability mentioned above, empirical deployment of the classification in contemporary case studies and dynamic analytical settings is required. Furthermore, linking the classified interventions with wider contextual positioning and mandates of innovation intermediaries is needed in order to expand from the classification framework's analytical into a normative function, useful for policymaking and organisational management.

Opportunities to develop such studies are extensive since the lack of understanding of innovation intermediary roles has been identified in many industry sectors. This is noted not only by analysts but also by practitioners, who often find themselves unable to operationalise the state of the art analysis offered in the literature. A recent example of a detailed sectoral analysis of the roles of innovation intermediaries can be found in Hannon, Skea and Rhodes (2014) analysis of the UK Energy Sector. The Space Sector, too, presents a great opportunity for such analysis since it can be used as an excellent comparative model for many high tech industries, and is currently undergoing an industry transition towards Open Innovation, which bring the role of innovation intermediaries to the fore. Specifically, Venturini and Verbano (2014) mention several understudied aspects of technology transfer and innovation intermediation in the Space Sector, advocating for an

> *"[…] Analysis of the intervention of brokers (including private) and other organizations devoted to facilitate the transfer such as incubators, venture capital companies, science and technology parks;" (Venturini & Verbano, 2014:109).*

I choose the emerging Space Sector in Scotland as the most optimal context in which to develop the topology parameters, as this field satisfied the above methodological requirements, has the appropriate size and make-up of the system and is timely with respect to the developmental trends present in this region and sector. Though vary of significant contextual influences on sectoral makeup (Martin and Scott, 2000), I believe the intensity of intermediaries' presence in this sector due to political impetus and relatively large up-front investment costs are providing us with a rich set of examples enabling for a high level of completeness in our study.

The pressing need for further understanding of these organisations is growing in particular in the "New Space" segment of the sector, where economic development seems to depend on models of intermediaries-facilitated open innovation processes inside Living Laboratory-like loose configuration of actors (Vidmar, 2019b; Vidmar *et al.*, 2020). Hence, building on my past work in the Scottish New Space sector based on participatory action research of this selected geographically-bound sectoral system of innovation (GSSI), I propose to develop a typology of the established classes of interventions, which takes into consideration new empirical findings related to practitioners concerns and their policy requirements as well as operational constraints (Klewitz, Zeyen and Hansen, 2013).

In this paper, my methodology is combining recently proposed classification framework based on extensive literature review (Vidmar, 2018) with empirical evidence from extensive and sustained ethnographic observation (Bryman, 2016), a sector-wide social network analysis (SNA) (Steketee, Miyaoka and Spiegelman, 2015) and a set of in-depth case studies (Yin, 1993). It is important to note that I am undertaking a two-phase approach to this inquiry, basing the identification of the sectoral features and roles of innovation intermediaries from the perspective of the recipients of their interventions, i.e. SMEs in the Scottish Space Industry. This part of the research is composed of a series of in-depth qualitative interviews with members of management teams based on a study of SMEs' innovation networks and new product development processes. I am then moving on to interrogate secondary literature and survey selected intermediaries' staff to illuminate their fit within the established understanding and the developing typology.

This paper begins with a brief presentation of the already developed innovation intermediaries classification, in particular, focusing on the relationship between innovation intermediaries interventions and systemic roles, thus proposing a typological model. After describing the methodology of this study, I outline the make-up of the innovation intermediation provision in the Scottish Space Sector through a broad ethnographical mapping exercise. I will first describe their sectoral positioning through SNA analysis of innovation networks. Then, I will outline selected case studies of the key interventions deployed in the sector, based on ethnographic work, secondary document analysis and a small survey of staff. Finally, in the discussion section, the case studies are explicitly linked to the four-fold typological understanding of high-tech innovation intermediation interventions, as *enablers, equippers, shapers* and *movers*.

Aims: Building an Innovation Intermediaries' Interventions Typology

Innovation intermediaries' typologies are abundant in the existing literature. For instance, working in the agricultural sector in Kenya, Kilelu et al. (2011) identify four different types of innovation intermediaries as Systemic Brokers, Technology Brokers, Enterprise Development Support and Input Access-Focused Intermediaries. There is another similar typology derived empirically by Colombo, Dell'Era and Frattini (2015), who propose four types of innovation intermediaries as Connectors, who gather information regarding the experience and competences, Brokers, who identify the sources of knowledge, Collectors providing solutions and Mediators who are establishing relationships. Another such typology is forwarded by Kim (2015) who describes four overarching "roles" as Knowledge enabling, Facilitating relations, Facilitating learning, Managing Interfaces. Although these typologies might be functional for the analysis they are developed for, they are based on two problematic premises required for a more holistic study of the field: a potentially incomplete definition of innovation intermediaries and a functional focus on distinct "roles" rather than examining (mixes of) interventions.

For instance, a detailed analysis of innovation intermediation literature, by comparing and contrasting examples of past attempts at classification of the various intermediaries' tools (Howells, 2006; Dalziel, 2010; Kilelu *et al.*, 2011; Nilsson and Sia-Ljungström, 2013; Kivimaa, 2014; Kim, 2015; Lukkarinen *et al.*, 2018), led to the establishment of a new structured classification of innovation intermediaries' interventions, as shown in Table 9 (Vidmar, 2018).

Most intermediaries will deploy a mix of the described resources and activities, whilst focusing on several key target intervention areas. The resulting eight classes of interventions

1. **Resources** – provision of infrastructure and tools for the use of innovation stakeholders
    a. **Infrastructure** – provision of system-level nationwide resources
        i. **Space** – networked provision of physical space for use by stakeholders
        ii. **Knowledge** – systemic provision knowledge (IP) for deployment in innovation processes
    b. **Tools** – provision of specific deployable resources
        i. **Equipment** – provision of specialist or otherwise inaccessible tools and devices
        ii. **Skills** – provision of expertise, advice and workforce
2. **Activities** – active engagement in defining and developing future innovation products
    a. **Framing** – activities deployed to facilitate wider system development
        i. **Interaction** – active development of opportunities for engagement of stakeholders
        ii. **Translation** – active brokerage between stakeholders and identifying development trends
    b. **Project –** activities on the level of a specific innovation projects to interlink stakeholders and further specific innovation pathways
        i. **Work** – active engagement with innovation projects and investment of staff effort
        ii. **Capital** – active deployment of resources (financial or otherwise) to an innovation project

Table 9 - Innovation Intermediaries' interventions classification

corresponded to the noted three "division lines" within the literature. These are based on the differences between the type of action deployed: splitting "activities" to enact a strong development vision versus developing and deploying innovation-enabling "resources";

“social” and “physical” interventions: i.e. the difference between deploying soft/relational or hard/material resources and activities; and employing high level or low level of direct involvement in the development.

However, expanding the definition and focusing on intermediaries’ interventions can leave the proposed framework exposed to lack of analytical and operational linkage to the organisational context within which they are deployed. Hence, a proto-typology linked to this classification was derived using the links between these divining lines in the literature and additional contextual factors related to their emergence. In particular, four main contextual factors were identified analytically as Close Involvement, Systemic Investment, Soft Leadership and Strong Mandate (Vidmar, 2018). These respectively correspond to loose pairings of intervention classes as Project and Infrastructure; Infrastructure and Tools; Tools and Framing; and Framing and Project. These are more broadly related to the tensions between the financial commitments in acquiring and deploying resources and political commitments in proposing and delivering activities, which are also moderated by a specific ecosystem’s evolution from emergence to maturity. However, these factors by themselves do not form a functional typology, as an additional understanding of their rationales and manifestations within the interventions is needed.

Examining the literature, some of several functional typologies have been formed. Kilelu et al. define six functions to innovation intermediaries interventions as “demand articulation/stimulation, network brokering, knowledge brokering, innovation process management, capacity building and institutional building” (Kilelu *et al.*, 2011, p. 13) and Klerkx and Leeuwis (2008) pose innovation intermediaries as solving five challenges: demand articulation, developing resources and competencies, dealing with market failures, financing, and overcoming system failures. Combining these key insights from the literature, I propose that the overarching innovation intermediaries’ interventions intentions can be framed as roughly four-fold:

1. To remove barriers for innovation by providing resources and action to address bottlenecks and challenges, with typical core intervention classes being Equipment Resources and Capital Activities.
2. To proactively create conditions encouraging innovation, with stimulus, promotion and investment with deploying Space and Skills Resources.

3. To create purchase in the innovation, especially by assisting in the development of markets, often external to the sector, through Interaction and Translation Activities.
4. To enact a particular vision for the future of the activity in a sector through delivering Work Activities and deploying Knowledge Resources.

Further integrating these intentions with the previously framed four proto-typological contextual factors: levels of investment or involvement and strength of vision/mandate or leadership; I propose a new typological model for contextual deployment of innovation intermediaries intervention as having four main types of roles/mandates:

1. Removing Barriers - Close Involvement – **Enabling the ecosystem**
2. Encourage Innovation - Systemic Investment – **Equipping the players**
3. Creating Purchase - Soft Leadership – **Shaping the common vision**
4. Enacting visions - Strong Mandate – **Moving the development**

These types of approaches to innovation intermediation cover a very wide range of actual deployment configurations of the classes of interventions, a deeper understanding of which would be necessary to operationalise this model. Past research shows that addressing such challenges is very context-specific (Martin and Scott, 2000; Klerkx, Álvarez and Campusano, 2015), depending on the sector, the (local) environment, etc. which leads to the vital role of geographically-bound sectoral systems of innovation framing for any specific analytical or operational study. Hence, in the rest of this paper, the derived typology will be tested within a specific context - the Scottish New Space Sector. In particular, I will be using a multi-method data collection and analysis to validate the key differentiating aspects of the four innovation intermediaries types.

Methodology

The initial empirical investigation of the innovation intermediaries in the Scottish Space Sector was completed deploying participatory ethnographic research (Crabtree, 1998; Darrouzet, Wild and Wilkinson, 2009; Blomberg and H Karasti, 2012) and document analysis (Bowen, 2009). Specifically, I was part of an innovation/business development team, which was just developing an innovation intermediation intervention. Moreover, I have taken part in several dozens of industry events, formal and informal, and conducted an extensive survey of the available literature and documents, in particular as pertaining to innovation policy, sectoral economic indicators, and analysed patterns of activities, most of which are presented elsewhere (Vidmar, 2020). Such work has been conceptualised as “strategic ethnography” (Pollock and Williams, 2010) and is inspired by the Biographies of Artefacts and Practices approach (Williams and Pollock, 2009; Hyysalo, Pollock and Williams, 2016). This work produced a detailed understanding of the “lay of the land” when it comes to innovation intermediaries, in particular, due to their central role in the sectoral development and integration (Vidmar, 2019b; Vidmar *et al.*, 2020). However, to understand the position of these innovation intermediaries within the studied sector and their significance for the sector’s development, additional research focusing on the structure of innovation networks is needed.

Social network analysis (SNA) is used widely to map out innovation networks within knowledge-intensive contexts (Giuliani, 2007a). In particular, ego-centric SNA or ego-SNA, which is based on collecting detailed information about the individual practitioners’ networks, is deployed to study the structural relationships between players in such ecosystems (Kolleck, 2013). Unlike the whole network studies which pre-define a network and then survey all members (nodes) within it, ego-SNA focuses on surveying a single originator node (ego) and its connection (ties) to others (alters) (Crossley *et al.*, 2015), through the open-ended name-generation process. This is based on filling out a detailed questionnaire in which characteristics of the interviewed actors partners and their relationship to them are examined. Based on this information, ego-networks (or ego-nets) can be graphed and analysed statistically. In addition, the whole network structure can be examined, if multiple ego-centric networks from the same population are joined together by assembling all ties in one network (Haythornthwaite and Wellman, 1996). Such a composite whole network can then be used to analyse the integration of actors within the larger context of studied innovation networks within geographically-bound sectoral systems of innovation as studied in this paper. Due to the overarching interest in the role of innovation intermediaries within the system the resulting composite network was studied as an instance of a “two-mode” network (Crossley *et al.*, 2015) – one relevant node being the originating ego-nodes and the other “bridging innovation intermediaries”, i.e. nodes who are of the right characteristics (entities having been identified in the earlier mapping exercise or very similar) and who are linked-to from at least two egos (in-degree centrality of more than 1).

Examining the role of various actors in integrating innovation networks can be achieved by measuring a node's centrality within the whole network. Traditional undirected centrality measures, such as closeness, betweenness and (in-)degree centrality, are inefficient in these circumstances, as they are based on network density (Marsden, 2002). In a composite whole network, the "originator" ego-centric nodes will always seemingly outrank all the other ones, in particularly obscuring and third-party "connector nodes" or bridges, which are nonetheless playing a potentially crucial role in integrating the whole network. These methods would also show a significant amount of "clustering" around "originator" ego-centric nodes, which is epistemically misleading for studies of composite ego-networks, since the clustering effect is not a phenomenological feature of the network, rather a result of the data collection technique. Hence, the only useful measurements of network positioning of all nodes are the rankings based on "in-degree centrality", which discriminate against the passive ego-centric "originator" nodes not linked-to from other "originators". As such, the resulting centrality ranking will reflect the interlining of the "originators" through either any of their ego-network alter members acting as bridges or directly, thus exposing the true degree of centrality of both egos as well as alter-bridges. Such measures are "authority" and "directed eigenvector centrality". The same goes for some of the other advanced directed centrality measures, such as the currently dominant PageRank algorithm used by search engines such as Google (Hajian and White, 2011). Hence, in the analysis of the innovation intermediaries positioning within the studied innovation network, a mix of the "authority", "directed eigenvector centrality" and PageRank was used, to show the pro-active linking paths between the ego-centric networks.

However, understanding particular nodes/intermediaries centrality is just the beginning of understanding how they got there. In particular, using case studies approach (Yin, 1993; Yin, Bickman and Rog, 2009), I examined the SNA's top-ranked innovation intermediaries' interventions, as correlated to the established four intentions/interventions areas outlined earlier. Since the particular interest in this work is the relationship between the mandate and its on-the-ground interpretation, supplementary data was collected using a short survey questionnaire, asking one member of staff at each targeted intermediary to provide a Linklater scale ranking of the importance of the various intervention classes to their programme, the reason behind such focus and how it has come about.[22] These were then studied in parallel to documents about these interventions and a narrative outline of the cases was produced as a starting point for a comparative analysis of the relationship between mandate, network position and intervention operationalisation.

Results: Innovation Intermediaries in the Scottish New Space Sector

The New Space Sector in Scotland is a very interesting example of an emerging high-tech regionally-bound sectoral innovation system, which has over the past 10 years undergone a transformation from an emergent conceptualisation of opportunities in this arena to a mature industry with global recognition. The ability to chart some of the key intermediaries interventions in this sector over this evolution can illuminate not only the modelled or intended interventions classification and deployment, but crucially can track their success or otherwise in the complex socio-economic reality of a fast-paced economy.

In particular, currently, the global Space Industry is in a time of transition, from the "classical" to the so-called "New Space" era (Adlen, 2011; Devezas, 2016; Vidmar, 2020). From cheapening of base technologies to miniaturisation and creation of satellite constellations to a more open and accessible satellite data, new geo-information services, enabled through Space assets, are being developed at an accelerated rate. In Scotland, this has been seized by researchers, entrepreneurs and policy-makers alike, and a vibrant sectoral innovation system has emerged. Such development was supported by a targeted set of interventions, which had a very significant impact on the sector's emergence and development in the region, supporting the establishment of regional and global primes, as well as a pan-regional value chain integration (Vidmar, 2020). Further initiatives are currently being rolled out in order to support the sector's maturation and encourage growth through supporting start-ups and spin-outs.

[22] To check for completes of my understanding of the landscape, a snowball question to identify all other innovation intermediaries within the GSSI was also included. Results showed near complete alignment with the analysis resulting from my ethnographic mapping exercise.

The Scottish New Space Innovation Intermediation Landscape

Building on the in-depth participatory action research within this ecosystem I have drawn a comprehensive list of the key innovation intermediation actors active in this arena in the UK, and specifically in Scotland, which is presented in Box 2 below.

European Space Agency (ESA) is an international organisation for Space Exploration, which includes member states from Europe and beyond. It operates a network of research centres across Europe and many manned and unmanned missions including extensive projects such as European Union (EU) backed development of the new global navigation satellite system (GNSS), Galileo, and Earth Observation service, Copernicus. As part of its core mission, it is investing in technology transfer and business growth, which it stimulates by commercialising its intellectual property, supporting a series of business incubators and running competitions for entrepreneurs. In the UK, ESA has a research centre, **European Centre for Satellite Applications and Telecommunications** – **ECSAT** in Harwell, whilst also supporting pan-UK STFC-run series of business incubators **ESA BIC UK** and a network of **ESA Business Application Ambassadors**. Furthermore, through the Galileo and Copernicus programmes, ESA runs a series of entrepreneurship development competitions, such as the **Galileo Masters** and **Copernicus Masters**.

UK Space Agency is the UK Government's executive agency with the remit of coordinating government's activities in the Space Sector. It is primarily set up to fund and steer programmes related to UK participation in international Space Exploration, developing new UK missions and commercialising Space technology. The UK Space Agency also coordinates the **Space for Smarter Government** programme, which aims to "unlock the potential of space to enhance public sector services and reduce costs" (UK Space Agency, 2014a) as well as backing incubation facilities developed by partner organisations (UK Space Agency, 2017).

Innovate UK is the UK Government agency promoting innovation and growth, part of UK Research and Innovation group. Developed from the Technology Strategy Board, it administers funding for R&D and business development, particularly in high tech. It is providing most of the funding for the current development of the network of technology transfer centres, called **Catapults** (including the Satellite Applications Catapult), and the **Knowledge Transfer Network** (KTN) (which also has a Space section). **Satellite Applications Catapult** is an independent innovation and technology development company, created by the Innovate UK to foster growth across the economy through the exploitation of space. They provide technical and business support, including access to facilities, and work to integrate and promote the Space Sector. They operate a series of regional centres, which they established through a competitive bidding programme, including the **Scottish Centre of Excellence in Satellite Applications (SoXA),** at the University of Strathclyde.

Scottish Enterprise (SE) is an executive agency of Scottish Government, tasked to develop businesses in Scotland under the devolved administration, with particular remit over the Central Belt (SE and SW Scotland). Its key objective is support for new venture creation, business development and growth (particularly in exports). SE coordinates the activities of several regional trade-association/chamber-of-commerce-like bodies, including **Aerospace, Defence, Marine and Security Industry Leadership Group,** which acts on behalf of the Space Sector. SE works in close partnership with **Scottish Development International (SDI)**, the Scottish Government agency tasked with inward investment and the **Highlands and Islands Enterprise (HIE)**, SE's sister agency with a remit in the North of Scotland and particularly active in the development of spaceports.

UK Space is a trade association for businesses operating in the Space Sector in the UK. It plays a significant role in shaping the **Space Innovation and Growth Strategy (Space IGS)**, which is the key a government-backed initiative to develop the sector. Establishment of the UK Space Agency and the prominent role the Space Sector has in the UK government's economic growth policies is based on this initiative. There are many key international players with crucial infrastructure in the UK and some in Scotland. In particular, the UK has several of the core **Airbus, Finmeccanica** and **Thales** Space-related subsidiaries and facilities, with part of the multi-national corporation **Leonardo**, a defence business with some space-related products being located in Edinburgh. There are also a number of large UK firms with a significant Space portfolio, such as **QinetiQ, BAE Systems** and **e2v**.

Science and Technology Facilities Council (STFC) is also part of the UK Research and Innovation (UKRI) family of funding and support agencies developing academic and applied research in the UK. Two other research councils also have a significant stake in the Space Sector, namely Engineering and Physical Sciences Research Council (EPSRC), which is supporting the development of advanced materials and engineering solutions for Space Exploration, and Natural Environment Research Council (NERC), which is supporting the development of applications in Earth Observation (EO). **UK Astronomy Technology Centre (UK ATC)** is the only STFC research facility in Scotland, based at the **Royal Observatory**

Edinburgh (ROE). They specialise in building infra-red (IR) detectors, data pipelines for microwave and radio telescopes, and complex systems engineering. **ATC Innovations** is the commercialisation arm of UK ATC, tasked with technology transfer and business relationships, including the new **Higgs Centre for Innovation,** comprising an ESA and UK Space Agency backed business incubator. The other main space-related STFC facility is the Space arm of the Rutherford-Appleton Laboratory in Harwell, the **RAL Space**.

Universities in the UK have a longstanding tradition of excellence in research in natural sciences, including Space Exploration. In Scotland, **Universities** of **Dundee, Strathclyde** and **Edinburgh** have the most significant research programmes in this area, in electronics, systems engineering, and data applications, respectively. There are a wider variety of consultancy and commercialisation efforts on behalf of these universities, in particular through spin-out and knowledge transfer programmes. There is also a series of technology incubators in Scotland, for example, Edinburgh based **CodeBase, TechCube**, the **Science Triangle,** and **Alba Innovation** (in Livingston), all of which take in companies with Space-related innovations.

Box 2 – Key players in shaping the innovation intermediation landscape for the expansion of the Scottish Space Sector based on the summary of my own participatory ethnographic analysis.

Examining the policy aspects of the sectoral development, the role of innovation intermediaries was noted as crucial, in particular as the governmental policy to develop this sector is based on delivering dispersed interventions in supporting innovation, rather than a unified national programme (Vidmar, 2020). Additional insight as to the importance of these innovation intermediaries comes from understanding the critical role the innovation intermediaries play in this ecosystem, as expressed by the key firms involved in its activities. Hence, the next section outlines the results of a detailed examination of the innovation network, which is placing the innovation intermediaries at the heart of this emergent regionally-bound high-tech sector.

Innovation Intermediaries in the Scottish New Space Sector's Innovation Network

Examining the innovation networks, specific structural trends were established among the SMEs, such as increasing network density for the younger, more "New Space" SMEs and grow of the importance of public partners. However, by plotting all network edges (i.e. connections between two partners) in the same network space, it became apparent that the most central actors in the network, connecting the diverse firms together, are organisations fitting the conceptual description of innovation intermediaries, as can be clearly seen in Figure 13.

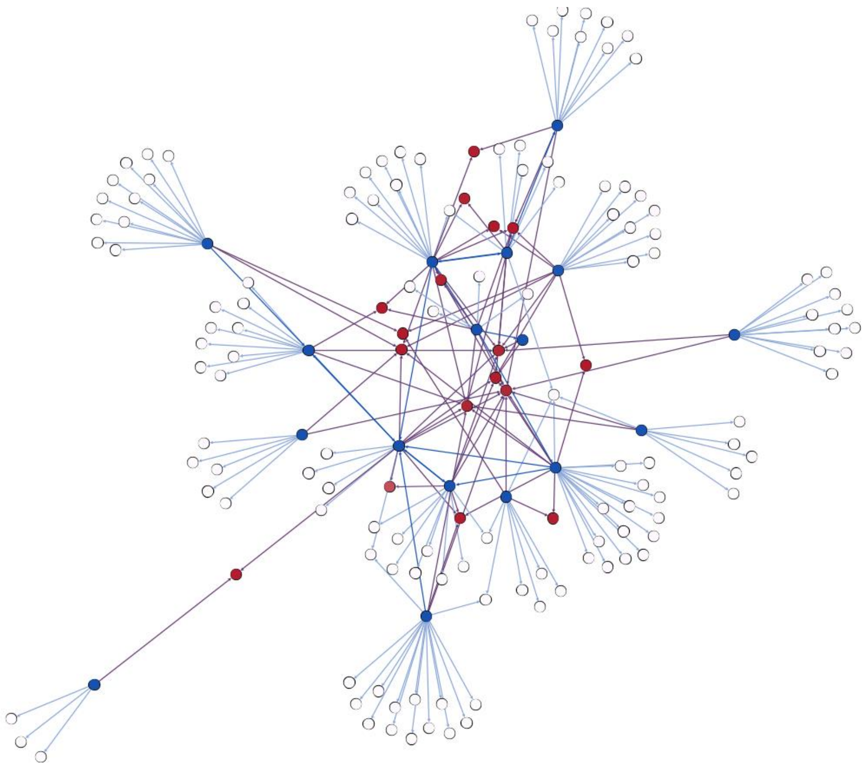


Figure 13 - Scottish New Space SMEs' innovation network, plotted with Gephi (0.9.2) software using Hu's proportional algorithm (Hu, 2005). *The colours are highlighting the originating ego-centric SMEs (nodes marked in blue) and the innovation intermediaries, research centres and governmental agencies (marked in red).*

In particular, as seen in Table 10, using the measures of in-degree centrality, directed eigenvector centrality, authority and PageRank, several organisations with innovation intermediation functions were identified as the most central nodes in the network. In particular, the five most central nodes are the European Space Agency, Scottish Enterprise, UK Space Agency the Satellite Applications Catapult and Innovate UK. There are some small discrepancies in-between the exact rankings produced by the three different computational methods, as they vary in their iterative algorithms. As an analytical check-up, the undirected versions of the three computational methods were tested as well, showing consistent results – through some of the originator egos outranked them, the top alter-bridges were the five listed innovation intermediaries (the simple undirected eigenvector centrality is shown in Table 10 for reference). Apart from egos and non-private organisations listed in Table 10, in the whole sample there are only four other alter-bridges, which are all (larger) corporations (Airbus, SSTL, OHB and Reaction Engines).

Non-Private Nodes (Innovation Intermediaries, *Research Centres* and Governmental Agencies)	In-degree Centrality (rank) (sorted)	Undirected Eigenvector Centrality (rank)	Directed Eigenvector Centrality (rank)	(Directed) Authority (rank)	(Directed) PageRank (rank)
European Space Agency (ESA)	11 (1)	0.75 (4)	0.79 (2)	0.40 (1)	0.010 (2)
Scottish Enterprise (1.2)	8 (2)	0.56 (8)	1.00 (1)	0.29 (3)	0.011 (1)
UK Space Agency (2.2^)	8 (2)	0.67 (5)	0.76 (3)	0.35 (2)	0.009 (4)
Satellite Applications Catapult (2.3)	6 (3)	0.48 (11)	0.72 (4)	0.25 (5)	0.010 (3)
Innovate UK (2.2)	6 (3)	0.47 (12)	0.47 (8)	0.25 (4)	0.008 (5)
University of Edinburgh	5 (4)	0.36 (16)	0.20 (35)	0.19 (8)	0.008 (6)
University of Strathclyde	4 (5)	0.40 (14)	0.63 (5)	0.21 (7)	0.007 (10)
Scottish Centre of Excellence in Satellite Applications (SoXA) (2.4)	3 (6)	0.35 (19)	0.30 (17)	0.12 (10)	0.007 (15)
Space Network Scotland (1.3)	3 (6)	0.12 (40)	0.02 (69)	0.07 (36)	0.007 (14)
RAL Space (2.3*)	2 (7)	0.21 (24)	0.61 (6)	0.09 (18)	0.007 (17)
NASA	2 (7)	0.13 (35)	0.37 (12)	0.05 (49)	0.007 (8)
DLR	2 (7)	0.15 (34)	0.03 (68)	0.09 (19)	0.006 (21)
UK Government (2.1)	2 (7)	0.16 (33)	0.12 (38)	0.08 (20)	0.006 (27)
Data Lab	2 (7)	0.19 (27)	0.10 (41)	0.10 (16)	0.006 (28)
University of Leicester	2 (7)	0.19 (28)	0.13 (36)	0.10 (13)	0.006 (31)
Scottish Government (1.1)	2 (7)	0.17 (32)	0.07 (40)	0.10 (15)	0.006 (38)
Herriot-Watt University	2 (7)	0.17 (31)	0.03 (67)	0.10 (12)	0.006 (39)

Table 10 - Top ranking innovation intermediaries extracted from the whole network of the Scottish New Space Sector using applicable SNA measures of centrality.

In addition, organisational hierarchies of closely linked organisations are listed in brackets next to their names. There are, in particular, two key groupings: the Scottish Government oversees the Scottish Enterprise (development agency), who founded Space Network

Scotland; and the UK Government's innovation agency, Innovate UK, is the parent body of the Satellite Applications Catapult, who in turn have set up the Scottish Centre for Excellence. There are a few additional hierarchical relationships (denoted by ^ and *) - UK Space Agency is an executive branch of the UK Government, whilst RAL Space part of one of the Science and Technology Facilities Council's national laboratories, ultimately also under the responsibility of the UK Government.

Though the identified non-private alter-bridges were notionally split analytically into the innovation intermediaries, research centres and governmental agencies, focusing on innovation intermediation intervention, most will deploy such resources and deliver activities. These results show both the central position of these actors, as well as point towards a need for understanding the role(s) of their interventions within the studied regional-sectoral system of innovation. Using the ethnographic data collected earlier on characterising the most visible intervention, a small series of case studies below (for more detail see Annex 2) outline the emerging four key types of intervention as previously identified in this papers opening proposition.

Selected Innovation Intermediation Interventions' Case Studies

So far, the analysis was centred on organisations and intra-organisational relationships. However, consistent with the proposed approach to focus on innovation intermediation as a set of interventions, I argue that in order to understand the central position of innovation intermediaries within the studied New Space Sector in Scotland a deeper case-study analysis of the interventions is needed. Table 11 outlines the key interventions these central organisations deploy, as identified through ethnographic work and embeddedness into a gatekeepers' team. In particular, this analysis points towards a multiplicity of intervention classes deployed simultaneously and the consequent multiplicity of roles. The critical programmes identified were (more details on the case studies in Annex 2):

- Copernicus Masters competition run by the European Space Agency (ESA) led the investment in early-stage projects in satellite applications and promoting the downstream part of the sector, with significant impact on the Scottish New Space Sector SMEs, for instance (Stevenson) Astrosat. With strong award focus on capital investment and R&D support, this was characterised as a predominantly "enabling" intervention.

- SMART: SCOTLAND grant awards were provided to a host of upstream SMEs (STAR-Dundee, Alba Orbital) by the Scottish Enterprise. Together with the evidenced change in the innovation capabilities/culture (Boyns, Spires and Cox, 2009), this is another “enabling” intervention. Scottish Enterprise also funded the Space Network Scotland programme/organisation to facilitate interaction across the Scottish Space Sector, which was categorised as a “shaping” intervention.
- UKube-1, the by the UK Space Agency financing and project-management of the UK’s first CubeSat built almost entirely in Scotland (by Clyde Space, Bright Ascension, Steepest Ascent). With a strong project management involvement and a specific reference to the desire to build new knowledge, this is categorised as a mainly “moving” investment.
- Scottish Space Symposium and Data.Space Conferences, which played a critical role in facilitating the interaction and translation necessary for the formation of a common identity amongst the sectoral actors, were organised by the Scottish Centre of Excellence in Satellite Applications(SoXA) – a clear “shaping” intervention. They also co-coordinate a small incubation programme at Tontine in Glasgow (an “equipping” intervention).
- Higgs Centre for Innovation, Science and Technology Facilities Council’s (STFC) recently opened business incubator and innovation facility in Edinburgh, to support six new incubates per year for two years and offer space and expertise to other sectoral actors. With a strong focus on the provision of space and development of skills, this is an “equipping” intervention.

It is important to note that in addition to the analysed case studies, there are other key intermediaries and interventions, in particular, European Space Agency (ESA) and EU Frameworks providing a focal point for the development of international standards and certification, as well as conducting their own technology transfer initiatives (“enabling”-type interventions). An example of the former is the partnership with the University of Dundee and STAR-Dundee over Space Wire and Space Fibre on-board communications protocols for satellites[23]. Another example of support for innovation not captured here, significantly

[23] This relates to funding from The European Space Agency (contract numbers: 17938/03/NL/LvH – SpaceFibre; and 4000102641 - SpaceFibre Demonstrator), the CEOI-ST under University of Leicester (contract number: RP10G0348A02) and the European Union Seventh Framework Programme (FP7/2007- 2013) (grant agreement numbers: 263148 - SpaceWire-RT (SpaceFibre QoS) (funding to

important in the current maturation phase of the development of the Space Sector in Scotland, is the support for foreign investment, through UK government foreign aid programmes, such as UK Space Agency-run International Partnership Programme (IPP), as well as by deploying Scottish Development International (SDI), a Scottish Government inward investment support scheme - primarily acting in the capital investment in projects (an "enabling"-type intervention). For instance, the former is supporting an international expansion of Earth Observation Capabilities (in particularly for Edinburgh-based geospatial-information companies Ecometrica and Carbomap) (Ecometrica, 2017; Murden, 2017) and the latter assisted in bringing to Scotland key players from the global new space sector, for instance, Spire (Scottish Development International, 2015). Specifically, the SDI/Scottish Enterprise uses the Regional Selective Assistance (RSA) mechanism to "help projects that will create or protect jobs in Scotland" (Scottish Enterprise, 2019a). Furthermore, in terms of market-creation, several other programmes are reaching into this sector, for instance, the Space for Smarter Government demonstrators for public procurement and various agencies' funding schemes for analytical and practical product and service development[24], including the recent Challenge Funding available through the UK Industrial Strategy. For instance, some project funding comes directly from Innovate UK, with their online audit tool indicating 14 projects based in Scotland were funded with a total value of over £420.000 (by 2019)[25]. These are all predominantly "enabling"-type interventions.

Sectoral Landscape of Innovation Intermediation Interventions'

Using the quantitative data collected from the surveys with selected participants in the various projects/innovation intermediaries' staff, a comparative radio-graph of the foci of individual intervention groups was created. This is based on a Linklater scale (1-5) ranking of the provision of intervention classes within the given innovation intermediation programme. The results seen in Figure 14 show close matching to the qualitative analysis performed through the case studies outlined above, with UK Space Agency's UKube-1 particularly strong in the "moving" capital domain (as well as work); Scottish Enterprise / Scottish Space

---

University of Dundee) and 284389 - SpaceFibre-HSSI (VHiSSI chip) – EUR 374 995,23 for STAR-Dundee; (total value EUR 2.6M)).

[24] See: https://www.spaceforsmartergovernment.uk/

[25] For more details, please see: https://datavis.innovateuk.gov.uk/app/#/region=Scotland;sector=Emerging%20&%20Enabling;theme=Space;

Network ranked highest in the “enabling” capital, the work and the “shaping” interaction classes; SoXA being strong in many domains, covering predominantly the “shaping” interaction and translation and the “moving” work and knowledge; and the STFC’s Higgs Centre for Innovation particularly strong in the “equipping” space and skills interventions’ classes.

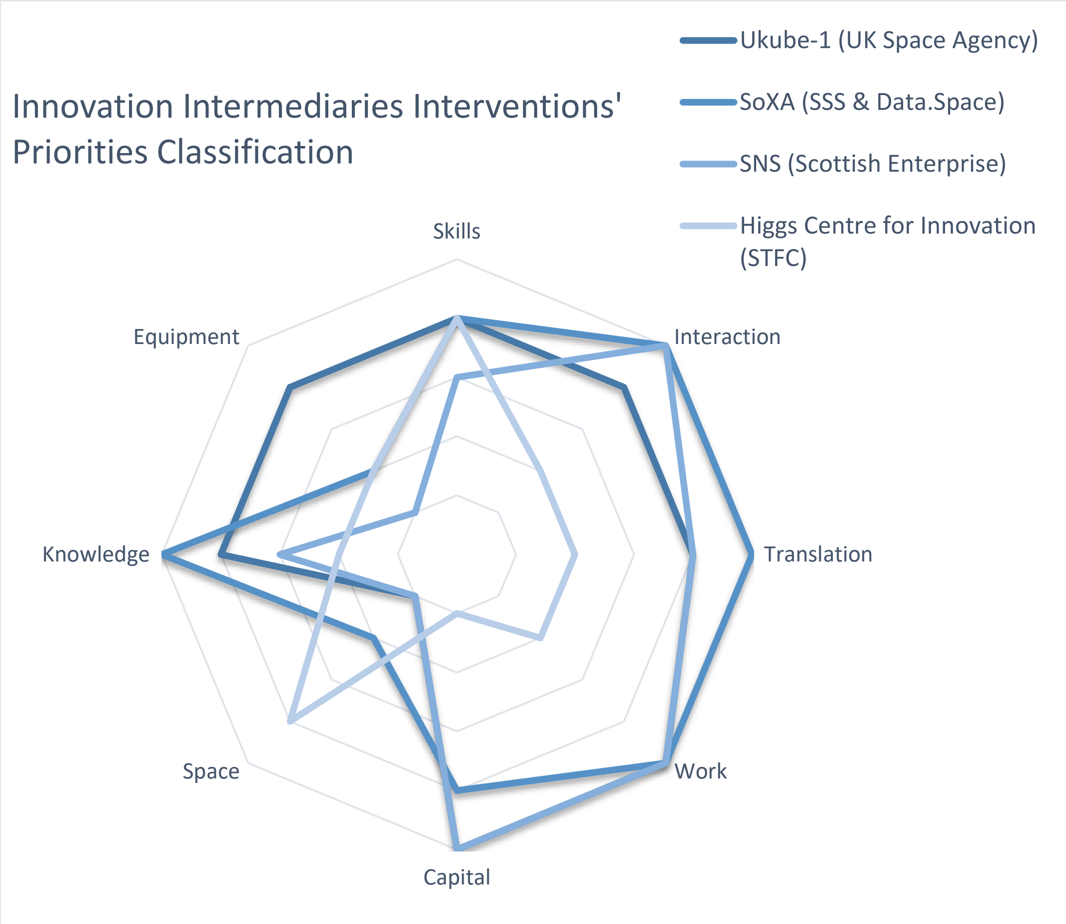


Figure 14 - Radio-graph of the survey-based mapping of selected innovation intermediaries interventions’ priorities.

Grouped Innovation Intermediation Organisations (from network analysis above)	Key Interventions (^ are captured in the case studies in Annex 2)	Key Characteristics (*from detailed case studies)	Intervention Classifications	Typological Classification
European Space Agency (ESA)	Copernicus Masters ^ -- Direct project investment	*Open international competition; Funding and other support to participants and winners -- Specific project management and funding through non-competition-based contracts for R&D	Capital Translation Equipment -- Work Capital	Enabling -- Moving
Scottish Government **Scottish Enterprise** **--** **Space Network Scotland**	SMART: Scotland Awards ^ -- Procurement Funding -- Space Network Scotland ^	*Open regional grants scheme; Funding to successful applicants -- Funding for SMEs and/or specific projects, through instruments such as Regional Selective Assistance (RSA) mechanism -- *Facilitating networking	Capital Skills -- Capital -- interaction	Enabling -- Shaping
UK Government **UK Space Agency**	UKube-1 ^ -- Regulation -- Project funding	*Directly designed project with lead partners; Funding and project management -- Developing a regulatory framework (policy and law) -- Funding for projects, for instance, the International Partnership Programme (IPP), Space for Smarter Government (SSG) demonstrators, etc.	Work Capital Knowledge -- Interaction Translation -- Capital	Moving -- Shaping -- Moving
UK Government **Innovate UK**	Project funding and work	Management (**SoXA**) and funding (Innovate UK) of projects	Work Capital	Moving

-- **Satellite Applications Catapult** **--** **Scottish Centre of Excellence in Satellite Applications (SoXA)**	-- Business development support -- Scottish Space Symposium ^ DATA.SPACE conference ^ -- Incubation at Tontine	-- Providing advice -- *Series of events of regional and international reach; Facilitating networking and discussions -- Providing business incubation space and support, events facilitation	-- Skills Knowledge -- Interaction Translation -- Space Skills	-- Equipping -- Shaping -- Equipping
UK Government **Science and Technology Facilities Council** **RAL Space / UK ATC**	Higgs Centre for Innovation ^	*Business incubator programme and innovation facility; Funding and access to expertise and equipment, events facilitation	Space Skills Equipment Knowledge Interaction	Equipping
NASA **DLR**	Project work	Leading (international) projects; Funding and management	Work Knowledge	Moving
Data Lab	Project work	Coordination of interaction through specific projects; Funding and management	Interaction Translation Work Capital	Shaping
University of Edinburgh **University of Strathclyde** **University of Leicester** **Herriot-Watt University**	Project work Spin-out	Involvement in specific projects; Management and access to expertise and facilities	Work Skills Knowledge Equipment	Moving

Table 11 - Cross-sectional analysis of the leading interventions by the identified central non-private organisations with intermediation function within the Scottish New Space Sector.

Furthermore, the new typology is not only analytically useful to enhance understanding but also operational/developmental tool for practitioners, both policy-makes and innovation intermediaries staff, as well as business development teams in firms and research organisations. To this end, and as part of the survey data collection with participants in the analysed case studies, additional questions about their assessment of needs for, and provision of, interventions within the Scottish Space Sector were included. Using the ranking scale of classes (1-8), the survey respondents were asked to rank the need for, and provision of, these intervention classes across the Scottish Space Sector. The results are presented on a bar chart in Figure 15. As the figure shows, capital, work and interaction classes of interventions are most well provided, whilst space is least so, and that the needs are more or less largest in these areas, too. However, using a simple subtraction, the balance of the interventions' demand and supply shows significant divergences. Most lacking is work (net difference of -1.3), the most over-provided is interaction (difference of +2.7), it is also lacking skills and equipment (-0.7), as well as space and translation (-0.3). Three seems a slight overprovision of knowledge and capital (+0.3). This show to a current strong presence of "shaping" interventions, with lack of "moving" ones.

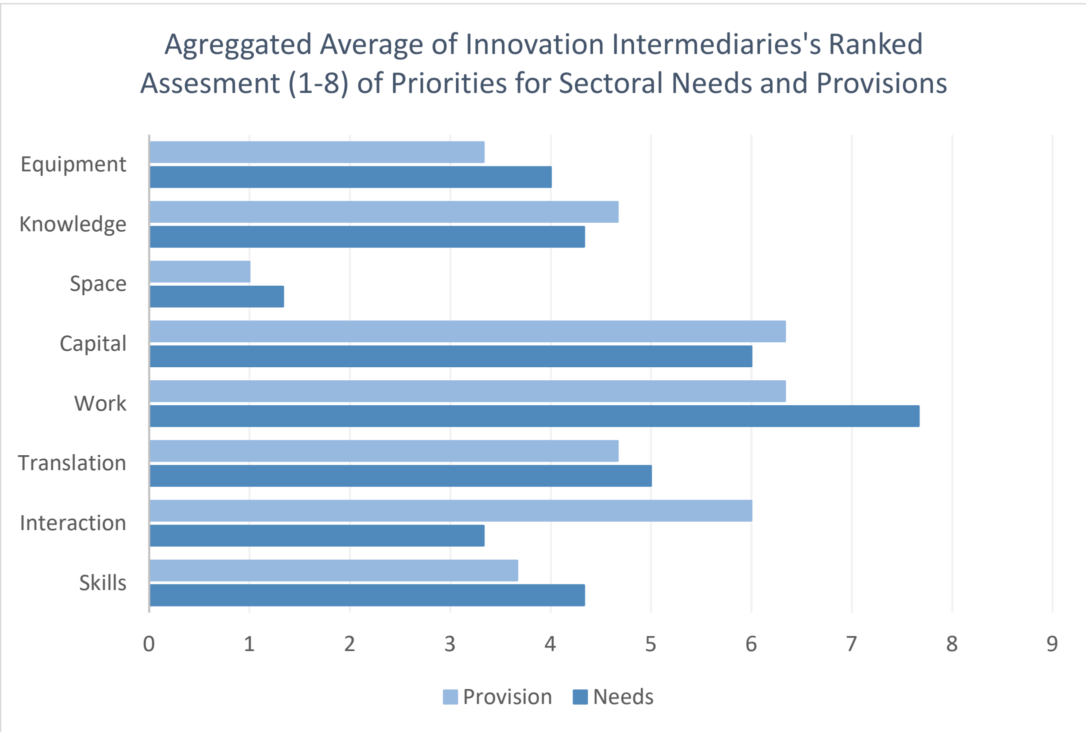


Figure 15 - Bar-chart of the aggregate averaged ranking of the need for, and provision of, innovation intermediation intervention classes within the Scottish Space Sector.

Consequently, for practitioners planning and/or assessing any intervention, a detailed needs assessment and (eco)system analysis is recommended (Duff, 1996), leading to the development of context-specific sets of interventions based on particular evidence-based theories of change (Clark and Taplin, 2012). A generic sample logic model, using the outlined intervention classes is attached in Annex 3. This is included specifically to relate this study to a key practitioners' concern, of how to make use of the proposed classification with an intervention programme development and execution. Furthermore, answering the – what to do? question is also critically linked to performance management and assessment (Clark *et al.*, 2013; Edler *et al.*, 2013; Copestake, 2014), and the classification presented above can also be deployed to construct evaluation exercises on intervention programmes through deployment a related classification measurable outcomes (sample of such structuring is also presented in Annex 3). The examples listed are illustrative and represent but a small sample of all available interventions and outcomes, with different organisations adopting a selection of which best suits the need of their sector and their goals, mandate and available resources.

Discussion and Conclusion: Innovation Intermediaries' Interventions as Enablers, Equippers, Shapers and Movers of an Emergent Innovation System

Returning to the proposed model consisting of the four main types of roles for innovation intermediation interventions and integrating it conceptually with the results of the quantitative and qualitative studies of the Scottish (New) Space Sector, the following conclusions can be drawn regarding the deployed interventions to provide the resources and activities for innovation. The innovation intermediaries' interventions are:

1. **Enabling the ecosystem** by removing barriers for innovation, with close involvement in investing capital and providing equipment. Here the managerially complex and sophisticated operations of the European Space Agency's Copernicus Masters programme and the Scottish Enterprise's SMART: SCOTLAND grants have shown the important direct support for specific R&D projects, securing them a central role within the Scottish Space Sector innovation network, with particular impact in the early stages of its development. Other funders (Innovate UK, Scottish Government, UK Government), whose

interventions are also classed here also have a prominent systemic role in bridging the actors in the network.

2. **Equipping the players** through deploying space and skills resources as a systemic investment. In this contexts, Higgs Centre for Innovation, and the smaller SoXA-led incubator at Tontine, are particularly interesting, though their immediate reach is so far limited as they were both only set up in 2018 and they do not feature in the network, though their various “parent” organisations do. Due to significant critical mass required to warrant the associated high level of investment, the recent establishment of such interventions is likely related to the growing maturity of the sector.

3. **Shaping the common vision** through interaction and translation activities as a type of soft leadership. Scottish Centre of Excellence in Satellite Applications (affiliated to Innovate UK’s Satellite Applications Catapult) and Scottish Space Network (funded by Scottish Enterprise) lead the interventions in this area, but are not as central in the innovation network, in part perhaps due to the very strong performance of their funding organisations. They exert “soft” brokerage role of predominantly facilitating interactions between actors. Given that, though the New Space segment of the sector is new, there has been existing R&D within a small number of firms and research organisation in the “traditional” space sector, these interventions normally associated with more mature sectors have instead emerged earlier and led the transition between the two “modes”.

4. **Moving the development** by delivering work activities and deploying specific (new) knowledge resources, which is linked to a strong mandate. Here, the UK Space Agency and the InnovateUK-SA Catapult-SoXA have the strongest presence, by project managing and knowledge brokering, and leading to a critical position in integrating the network. These are directly linked to national innovation policy in this arena (Vidmar, 2020) and hence very specific funding mandate. Other (international) space agencies (especially ESA) have a similarly strong presence here, alongside the lead local Universities and other funding and research organisations. The presence of these interventions since the early stage of sectoral development, as well as the multiplicity of roles/intervention-types the organisation's involved deploy, lead to these organisations being very centrally placed within the innovation network.

Hence, the proposed typological model has been able to capture the major trends within the development of an emerging sector. For analysts, this model can form the basis of a systemic view to the variety of roles intermediaries (can) play in innovation systems and can lead them to both recognising the importance of organisations providing interventions previously excluded from the intermediation typologies as well as find gaps in such provision. Due to the limitations of this study - especially the limited empirical data - this analysis shows that significant insight could be garnered from heuristic uses of the proposed model, both on the level of intervention's classification (resources/activities, physical/social, systemic/direct), the proto-typological contexts (close involvement, systemic investment, soft leadership and strong mandate) as well as the emerging comprehensive typology of roles (enablers, equippers, shapers and movers). It is further important to note that the above interventions' objectives are underpinned by processes of social learning within intermediaries (Hyysalo and Stewart, 2008; Ngwenya and Hagmann, 2011) and fitting wider innovation system development (Kivimaa, 2014), hence this model could be deployed as a valuable tool in mapping intermediaries evolution in the current attempt to better understand the dynamics of innovation systems development and all actors contained within. Further studies as to the emergence of any comparative differences in provisions across different sectors within the same socio-economical and political context (i.e. locale, region, state) or in similar sectors in different contexts, could illuminate the variety of underlying factors in decision-making to implement any of the typified interventions (Flanagan, Uyarra and Laranja, 2011).

Annex 1: Non-bridging Public Organisations in the Composite Whole Network of the Scottish (New) Space Sector

Nodes (only non-private organisations: Innovation Intermediaries, *Research Centres* and Governmental and Non-Governmental Agencies)	In-degree Centrality (rank)
Adam Smith Institute	1 (8)
Aerospace Trade Body	1 (8)
Asia Development Bank	1 (8)
Cambodian Government	1 (8)
Cape Peninsula University of Technology	1 (8)
CeeD	1 (8)
Code Base	1 (8)
Digital Catapult	1 (8)
ECOSUR (Mexico)	1 (8)
Edinburgh Centre for Carbon Innovation	1 (8)
ESOC (ESA)	1 (8)
ESTEC (ESA)	1 (8)
FarmAfrica	1 (8)
Fishing Watch	1 (8)
Forestry Commission	1 (8)
Future Cities Catapult	1 (8)
Horizon EU	1 (8)
INPE (Brasil)	1 (8)
Ireland Space Centre	1 (8)
James Hutton Institute	1 (8)
JAXA	1 (8)
Luxembourg Space	1 (8)
Malawi Government	1 (8)
Mercy Corps	1 (8)
NOAA (US National Oceanic and Atmospheric Administration)	1 (8)
Offshore Renewable Energy Catapult	1 (8)
Philippine Government	1 (8)
Rothamsted Research	1 (8)
SCOPAC	1 (8)

Nodes (only non-private organisations: Innovation Intermediaries, *Research Centres* and Governmental and Non-Governmental Agencies)	In-degree Centrality (rank)
Scottish Association for Marine Science	1 (8)
Scottish Development International	1 (8)
Scottish Environment Protection Agency	1 (8)
Scottish Rural University College	1 (8)
Space Agency (Foreign)	1 (8)
Space Growth Partnership	1 (8)
Tontine	1 (8)
UK ATC	1 (8)
UN	1 (8)
University of Dundee	1 (8)
University of Glasgow	1 (8)
University of Manchester	1 (8)
University of Maryland	1 (8)
University of Nottingham	1 (8)
University of St Andrews	1 (8)
University of Wisconsin	1 (8)
Vietnamese Government	1 (8)
World Bank	1 (8)
Zero Waste Scotland	1 (8)

Annex 2: Selected Interventions in the Space Sector in Scotland

Copernicus Masters (by European Space Agency and Satellite Applications Catapult)

Further to the development of a "brand" identity and cross-linking the sector, a critical dimension of the Scottish New Space Sector support for innovation is an open-ended direct investment in projects through R&D (funding). In particular, the industry has benefited significantly from the investment and exposure connected to a series of innovation competitions, some in broad areas (i.e. high-tech engineering) and some very specific for (New) Space. These originate from within the wider economic and sectoral (eco)system, in particular from governmental players (i.e. Scottish Government, UK Government, EU) and international organisations (especially European Space Agency (ESA), and in some cases NASA). The key examples here is Copernicus Masters awards, delivered under the European Space Agency. Though these are nominally competitions with R&D capital funding awards, they crucially also serve as a platform to develop the market for the emerging technologies, through encouraging the translation of research and development activities into commercial applications and provide opportunities for interaction and further sectoral identity/brand development.

In the Copernicus Masters programme, which is running since 2011, a downstream Scotland-based SME, (Stevenson) Astrosat, has won in at least one category in each competition between 2012-17. For instance, Astrosat's most successful projects were:

- WaveCERT - providing vital remote modelling allowing for prediction, monitoring, and surveying of tidal and wave potential anywhere in the world, based on a completely novel and remote means of surveying, monitoring, and reporting on site potential and existing infrastructure.
- ThermCERT - using space-derived data to enhance quality and scanning frequency over the lifetime of a thermal investment; increase the effectiveness of carbon credits/trading; and provide a suite of tools for targeting, measuring, reporting on, verifying, communicating, and promoting thermal efficiency investments.
- eXude system - providing an advanced flood-monitoring tool that makes use of the latest in SAR and radar altimetry data-processing techniques for flood identification and mapping (incl. urban areas). Coupled with the ability to receive additional data

sets, the system will provide information on drainage capabilities and hazard assessment/infrastructure failures within flood management infrastructures, both during events and in post-event analysis.

In fact, since 2018, the company itself, having grown and developed significantly on the back of this competition and other work, is a sponsor of a category within the Copernicus Masters competition (Disaster Management Challenge). The Satellite Applications Catapult was also a sponsor of several challenges (between 2015-2018). Other projects with Scottish involvement and Scottish start-up companies have also been attracted to the competition, for instance, HAB Forecast won 2013 Best Service Challenge[26] and Beinn Bike was the 2017 University Challenge winners[27]. Participants, and in particular winners of the various categories of the Copernicus Masters competition, receive "cash prizes, business incubation, business coaching, technical support, access to testing facilities, prototype development, publicity, marketing support, access to experts and access to public funding", which in 2019 is worth in excess of €450k (ESA, 2019a). In practical terms, In addition to directly supporting projects and SMEs, the Copernicus Masters programme is in being seen as

> *"an effective tool for disseminating information and messages about the benefits of space applications."* (Schrogl, 2017)

SMART Awards and Scottish Space Network (by Scottish Enterprise)

Similarly, the SMART: SCOTLAND awards is a funding and business development and promotion scheme, delivered by the Scottish Enterprise (Scottish Enterprise, 2019b). The SMART: Scotland award has been awarded to lead SMEs in the Scottish Space Sector since the early 2000s. In particular, STAR Dundee, a University of Dundee spin-off working with onboard satellite communications, has won two SMART awards in 2002 and 2006 respectively. However, so did the more recently established Clyde Space, a nano-satellite manufacturer and integration firm (in 2006 and 2017), as well as the latest New Space generation, for instance, Alba Orbital, for their own, even smaller (pico-)satellite and components development (in 2014); and to the incoming US-originating space tracking SME, Spire (in 2015). These awards are critical in the context of enabling the development of

[26] See: https://www.copernicus-masters.com/winner/hab-forecast-harmful-algal-bloom-forecast/
[27] See: https://www.copernicus-masters.com/winner/beinn-bike-smart-mountain-bike-route-planning/

applied R&D and are focusing mainly on an upstream segment of various high-tech sectors, including Space. In particular, the scheme itself describes its mission as helping

> *"[…] undertake technical feasibility studies and research and development (R&D) projects that have a commercial endpoint."* (Scottish Enterprise, 2019b)

With feasibility studies funding of up to £100k (expecting a minimum of 30-40% match funding from SMEs) and R&D project funding of up to £600k (with 65% match funding from SMEs) awarded through a competitive process through which SMEs

> *"[…] must be able to demonstrate:*
>
> - *That you own, or have rights to exploit, the intellectual property required to undertake the project*
> - *All intellectual property developed throughout the project will be owned by the company receiving grant funding*
> - *How commercial prospects for the end product or process will be achieved, with realistic and effective routes to market*
> - *That you have the necessary management and technical expertise and resources (either in-house or brought-in) to make the project a success*
> - *That both the project and the business are financially viable*
> - *That financial assistance from SMART:Scotland is essential"*
>
> (Scottish Enterprise, 2019b)

This is related to the programme's five aims, identified as

> - *"assist small and medium-sized enterprises (SMEs) to research, develop and exploit new, technically innovative, products with good commercial potential;*
> - *stimulate technical innovation and encourage best practice throughout business.*

- *strengthen the scientific and technological bases of industry;*
- *improve the future competitiveness of the Scottish economy by supporting technically innovative SMEs, recognising that these are a dynamic source of new wealth creation, employment and export sales; and*
- *help contribute towards a climate which encourages investment in innovative technology by individuals, companies and financial institutions and which stimulates a market in technological advancement."* (Boyns, Spires and Cox, 2009, p. 9)

Hence, SMART: SCOTLAND scheme is not only providing the necessary funding but also encouraging the development of innovation and business capacity. In a report evaluating the first ten years of the scheme's operation (1999-2008), the authors note that:

> *"[…] large majorities of grant recipients acknowledged that they had: improved their innovation culture; become better able to manage innovation; improved their innovation / technical understanding; and, invested more in innovation in general."* (Boyns, Spires and Cox, 2009, p. 7)

Scottish Enterprise also provides additional targeted business development support, including coordinating unified Scottish exhibition spaces at conferences, as well as funding a dedicated knowledge brokerage and business network development initiative, called the Space Network Scotland (SNS). Whilst SMART: SCOTLAND awards target capital investment in specific key technology development areas, the SNS is enabling the translation of interests across the sector and more widely into the economy, as well as more efficient sharing of resources. A surveyed partner on the programme noted:

> *"Space Network Scotland was created to provide a focal point and a resource for Scotland's space sector. Key to its activities is the identification and creation of opportunities […]"*

Mentioning also that these "are the areas where there is a provision that can be most beneficial at relatively low cost" as they explained that

"This focus came initially from discussions that Scottish Enterprise had with space companies in Scotland, was refined by the expertise of the SNS staff, and then further refined by feedback from industry following work that we undertook."

In particular, a recent internal review of the SNS work argued that:

"The overall conclusions from the questionnaire were that:

- *Most interest in support came from respondents who see themselves entirely or largely as space organisations.*
- *The priority interests of the sector are representation to government, marketing of the sector and networking events.*
- *Promoting Scottish capability in new space was equally popular with promoting space capability more broadly.*
- *Only around half of the companies that responded are currently members of a trade body.*

At the follow-on meeting the broad consensus was that support should continue to be light touch and response to the companies and universities that make up the network." (Space Network Scotland, 2017)

UKube-1 (by UK Space Agency)

Form the perspective of several lead players, a key transformational project in the Scottish New Space Sector was the UKube-1 project, a tender to design, build, launch and operate the first UK cube-sat. A cube-sat is a nano-satellite platform build of cube units (10-10-10 cm), weighing a few kilograms (ESA, 2019b). They were initially developed as training and outreach kits, though once several units (3+) are stuck together, they create a bus capable of meaningful space deployment. These cube-sats are one of the key innovations powering the New Space era of space exploration and industry, as their small size (enabled by miniaturisation of consumer electronics) and low cost (by using off-the-shelf components), enabled radically new technological solutions reaching a completely new market. In particular, their low cost and modular architecture make them almost "disposable" and in a low earth orbit location, their 18-month lifespan is short enough that the components need no radiation protection, making the craft lighter and hence the launch significantly cheaper. The low cost and industrial-scale modular integration is also enabling mass production of cube-sats, leading to the creation of constellations (i.e. several satellites orbiting the Earth in formation), where tasks can be distributed and revisit rates (flypast of the same area on earth) can be high (i.e. real-time monitoring from space becomes a possibility).

UK Space Agency led the UKube-1 project with the explicit intention of producing a technology demonstrator as a precursor to commercialising domestic cube-sat capability. The surveyed project participant noted that the main objective of UKube-1 was built around the “need to establish and develop upstream space capability in Scotland and UK”. In particular, there was a good opportunity to “use cost effective CubeSat missions to achieve this” and then leading to “provide further offerings with high export potential”. The initial idea for this project arose from academic research, supported by Knowledge Transfer Partnership scheme, between Strathclyde University and Clyde Space, then a leading developer of high-performance space-ready batteries, who wanted to expand their business in this interesting new technology area. Funding has been sought from the Scottish Government on a similar project called ScotSAT, but financial constraints of the post-economic crash era meant that the proposal was not successful. This is how UKube-1’s stakeholders are described by the UK Government:

> *“UKube-1 is an exciting and novel collaboration between the UK Space Agency, industry and academia. The funding partners for UKube-1 are the UK Space Agency, the Technology Strategy Board and STFC. The spacecraft is being developed through a Knowledge Transfer Partnership with innovative Scottish company Clyde Space and the University of Strathclyde, supported with internal funding from Clyde Space. The UK’s largest space company, EADS Astrium Ltd, is providing engineering and programme management support to the Agency for the pilot programme. UK industry and academia are providing the payloads and the ground support operations and the launch will be procured by the UK Space Agency.”* (UK Space Agency, 2014b)

Crucially, as noted in the text, the project was of interest to big space players as well (especially EADS Astrium, a large aerospace and defence multinational), who leveraged their influence through the then newly created UK Space Agency, to interest the government in this opportunity – the project participant I surveyed stressed that "use of lobbying and ministerial level support was critical". Building on a pre-existing consortium of national players, in particular academics interested to send instruments in space, and tapping into the contemporary political interest in innovation and the emergence of New Space trends, the core players involved in the feasibility studies (EADS Astrium, Strathclyde University and Clyde Space), pitched an (optimistic) mission plan to launch UKube-1 as a transformative opportunity for the UK Space Industry and consequently the UK economy. The surveyed UKube-1 participant, in particular, stressed the importance of

> *"buy-in from Astrium, who then supported us to engage with BNSC [British National Space Centre] and get [their] CEO [a] seat on the space leadership council."*

The programme was then run by the UK Space Agency with the very specific mandate (as noted in the quoted UK Government briefing above) and in a very hands-on manner, though funding was quite limited for most of the project. The participant mentioned some of these limitations specifically, noting that "while more knowledge might have been useful, the costs would likely have been prohibitive".

Overall, this intervention which involved an investment of capital and direct project work

> *"[…] helped maintain the UK's leading position in the CubeSat sector. Participation in the mission placed Clyde Space in an excellent position to capitalise on the fast-growing global nanosatellite market. The company has experienced 100% year on year growth, both in turnover and employees, as a direct result from involvement in UKube-1, and is firmly established as a global leader."* (UK Space Agency, 2015)

The effect of this was particularly strongly felt in Scotland, where the lead developers, Clyde Space, are based. The intention was also to translate this opportunity to a wider community of (New) Space subsystems and payload developers, which partially materialised, in particular for the Dundee-based on-board software developers Bright Ascension and the academic partners, Strathclyde University. These partnerships by and large endure and importantly add to the development of the Scottish New Space sector by continuing R&D and access to specific markets.

Scottish Space Symposium and Data.Space (by Scottish Centre of Excellence in Satellite Applications)

The Scottish Space sector has developed organically mainly in three distinct clusters, with extensive expertise in space data applications hosted in Edinburgh, space hardware developers based in Glasgow and a small number of sub-systems developers (mainly in electronics and embedded software) in Dundee. Though these disparate clusters grew and developed separately, various actors in the industry realised that a level of integration across the sector and region would be desirable as a bulwark against market fluctuations. In order to assist in this vertical value chain integration in order to create a unique selling point of Scotland being one-stop-shop for New Space solutions, a group at Strathclyde University, in partnership with their key contacts in the industry, has been developing a series of interventions to facilitate cross-sector interaction and regional coordination. In 2014 they also applied to host the Scottish Centre of Excellence in Satellite Applications (SoXSA). This is part of the UK-wide network of centres of excellence in the space sector, all linked to the Satellite Application Catapult, one of the main nodes in the "Catapult" network of innovation centres overseen by the UK government's innovation agency, Innovate UK. The SoXSA have engaged in a variety of programmes, both national (through their parent Catapult) as well as regionally and locally (more targeted project work and support for key partners). A highlight of the local programme is the establishment of a small incubation programme in partnership with Glasgow-based Tontine incubator and funded from UK Space Agency, which

> *"[..], will support six companies for an incubation period of one year. Throughout the incubation period, the companies will benefit from superb accommodation, unparalleled business support and access to a wide business network through SoXA."* (Tontine, 2018)

However, the wider regional programme is of most interest, as it created on promoting a new dynamic in the space sector in Scotland, a cross-sectoral regional integration. The surveyed member of SoXA team noted that:

> *"We aim to be "Scotland's place in space", building and supporting the space network, and generating high value projects to develop the sector and the Scottish economy.* […] We focus on connecting academia,

industry and innovation centres etc. to make the right people engage to benefit Scotland economically and otherwise.*"*

These activities were particularly brought to the fore in their pivotal role to assist meeting and networking in the sector, by running a series of Scottish Space Symposia (2010, 2012, 2015 and 2017), leading to more recently also organising an annual Data.Space conference (2017, 2018) with international reach hosted in Scotland. Scottish Space Symposia were explicitly designed to develop a community of actors in this emerging sector and engage in sector promotion. This description was used in the announcement of the 1st Scottish Space Symposium in 2010:

> *"Scotland is emerging as an international centre for a range of disruptive new space technologies. While this growing industrial and academic capability is recognised in sectors of the space industry, the profile of this capability needs to be raised in Scotland. In addition, the potential of Scotland to continue to grow in the space sector needs to be unlocked by developing a strong sense of community and reaching out to industry and university groups who do not yet recognise the opportunities space can provide."* (*1st Scottish Space Symposium - University of Strathclyde*, 2010)

In particular, the event was designed to provide:

> *"[…] An opportunity to network with the Scottish space technology community*
>
> *A forum to identify key capabilities, future partnerships and opportunities*
>
> *A platform to raise the profile of the Scottish space technology community"* (*1st Scottish Space Symposium - University of Strathclyde*, 2010)

This mandate was carried over and expanded to an international reach when Data.Space was announced. In particular, it was centred on

> *"[…] bring[ing] together data users from across the economy with data generators from the space sector as well as pooling innovators and*

> *entrepreneurs from academia and the commercial sector with regulators, legislators and venture capitalists."* (Satellite Applications Catapult, 2014)

Both of the events had a very successful run and the ideas behind the value chain integration resulted in the establishment of the Agile Space group, a loose industry consortium, which was announced at Data.Space 2017, though it has not become fully active yet. Similarly, the concept of regional integration has received attention by the Scottish Government Industry Leadership Group (on Defence, Marine, Security and Aerospace) in their 2016 Strategy, with a special sub-committee for Scottish Space Industry Action Plan being formed at the time. These activities and ideas framed the development of the space sector in Scotland "brand", with a unique selling point related to regional competitive advantage. The branding is focusing on Scotland becoming the "one-stop-shop" for (new) space solutions with partner companies producing hardware, launching payloads, operating space assets, collecting data and extracting information for the customer. Though several components of the value chain are still in development (in particular the launch capability), this image of Scotland as a key "space hub" has gained political and economic traction within and outwit the sector.

Higgs Centre for Innovation (by Science and Technology Facilities Council)

As per many sources of analysis listed previously, the Scottish Space Sector was found to be lacking several key elements of the innovation intermediaries provision. In particular, there is a lack of access to specialised equipment and physical space, as well as more targeted activities to disperse knowledge and skills. Hence, emerging organically from industry demand and public policy supply, the Higgs Centre for Innovation was designed to fill this gap. Higgs Centre for Innovation in Edinburgh is part of the effort to spread the reach of STFC's support for innovation to Scotland (STFC, 2013), as the project strives to create a regional incubator, closely linked to STFC's UK Astronomical Technology Centre, based at the Royal Observatory Edinburgh. In Autumn of 2013, the plans for this new intermediary were announced in a press release as:

> "A new Higgs Centre for Innovation announced today (5 December 2013) aims to create new market opportunities whilst also inspiring the next generation of scientists and engineers. […] [which] *will apply business incubation best practice to big data and space technology,*

enabling start-ups to translate fundamental research into wider commercial impact." (STFC, 2013)

In order to deliver on this mandate, the centre is planned to:

"[...]

- *House and incubate up to 12 high-tech start-up businesses*
- *Support them with a comprehensive package of business training, technical advice, and access to equipment and facilities*
- *Provide PhD students with direct experience of entrepreneurial environments*
- *Offer to SMEs access to specialist labs and test facilities for micro/nano-satellites housed within dedicated clean-rooms"*

Furthermore,

"[...] The BIC is part of the European Space Agency (ESA) BIC UK, CERN BIC, and UK Space Agency (UKSA) BIC networks."* (STFC, 2018)

As well as being run in partnership with the University of Edinburgh.

Crucially, this type of intervention requires significant financial investment and are difficult to establish without a pre-existing emergent ecosystem (including a critical mass of companies) and a significant social capital (most often built on past track record and/or existing infrastructure). In this case, this manifests as:

"The Science and Technology Facilities Council (STFC) received a capital investment of £10.7M from the Treasury to construct the new centre. STFC will invest £2M over five years to operate the centre." (STFC, 2013)

and

"The new centre will build on the success and proven track record of similar models seen in the STFC ESA and CERN Business Incubation Centres as well as the Innovations Technology Access Centre."

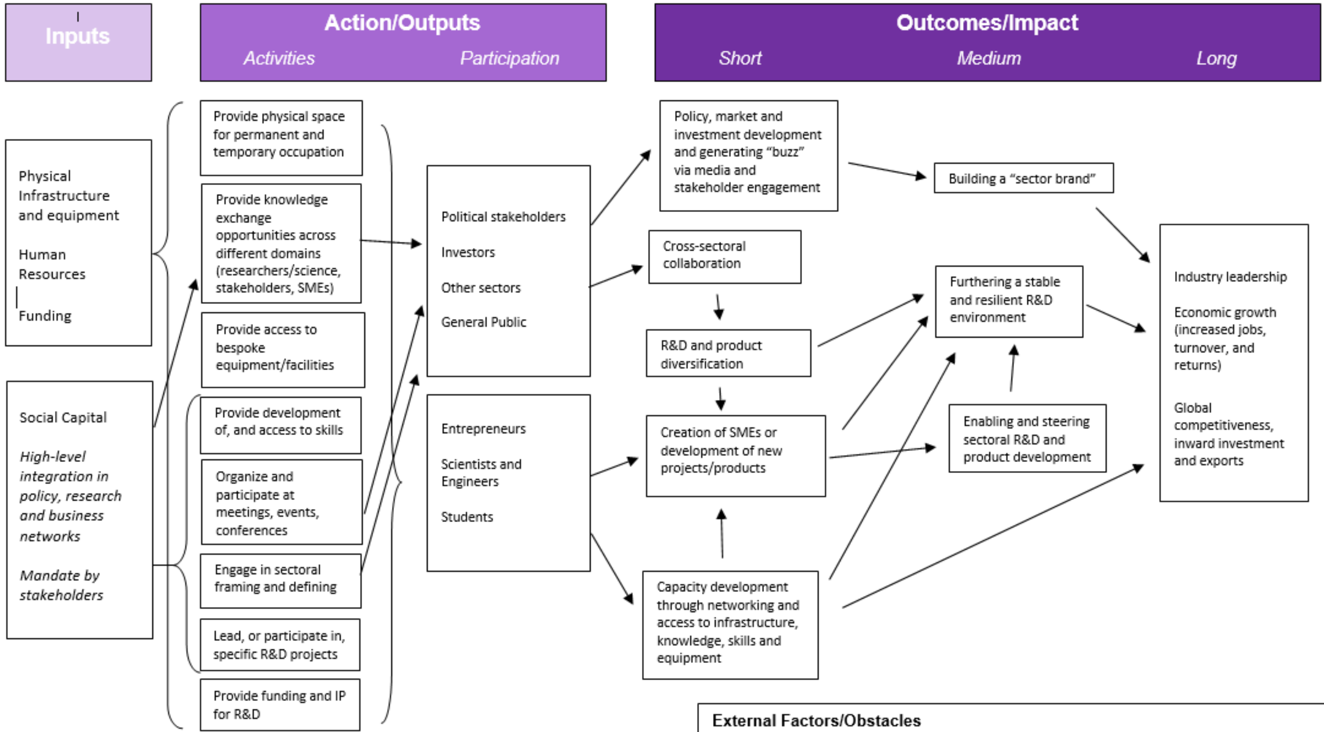
The centre construction was completed in early 2018 and it is about to start its operations later in 2018. Crucially, due to the significant amount of public funding involved in this project, the steering vision for the centre is far more modest, in line with the “neutrality” conceptualisation. Also of note is the extensive start-up and spin-out focus, engaging with the early-stage innovation process and emerging opportunities and markets. As expressed by the surveyed member of the Higgs Centre for Innovation staff, their aim is “to make links between academic research and the commercial world”.

Annex 3: Template Logic Model and Model KPI Outcomes

- Logic Model -

Programme: Innovation Intermediaries in an Emerging High-Tech Sector

Situation: *Unavailability/inaccessibility of Infrastructure & equipment, and specialist knowledge & skills shortage amongst SMEs in low-TRL R&D*
Lack of sectoral identity and focus to create new markets and funding streams leading to difficulties with creating commercially viable products in early stage of sectoral development



Assumptions
By providing resources and steering development through various types of direct actions, intermediaries can accelerate sectoral development.
Financial and business development support key for SMEs
Networking and access to expertise/research and facilities key for businesses growth

External Factors/Obstacles
Global economic trends (market shaping)
Political climate (change of mandate, focus, funding)
Issues with finance (investment competition) and "valley of death" (scaling)
Scientists reluctant to engage with business and knowledge transfer
Geographical and growth challenges

Template Source: http://www.uwex.edu/ces/pdande/evaluation/evallogicmodelworksheets.html

Table of measurable outcomes related to interventions types – Key performance indicators (KPIs)

	RESOURCES		ACTIVITIES	
	INFRASTRUCTURE	TOOLS	FRAMING	PROJECT
Physical	**space** Measurable outcomes: size of available space; tenant uptake; number and frequency of hosted events; impact of hosted events	**equipment** Measurable outcomes: value of the equipment; frequency of use; impact of use on R&D projects; development and value of any new tools created	**interaction** Measurable outcomes: number of attended events; number of delegates attending events; media coverage of events and meetings; high-profile endorsements; event outcomes (papers, reports, further meetings, partnerships made, contracts signed)	**work** Measurable outcomes: number of projects worked on; amount of time invested; level of activity (leadership, management, task leads, technical work); diversity of projects and partners; project outcomes (design, prototype, testing, product on the market, revenue generated, business turnover)
Social	**knowledge** Measurable outcomes: number of papers published; citation impact; licensing/use of patents; use of mapping and database tools	**skills** Measurable outcomes: number of hours and (monetary value) of hired expertise; number of attendees at training programmes; number of informal partners; number of outreach and recruitment events and their impact	**translation** Measurable outcomes: number of policy papers and briefings; impact of policy activities (changes to regulation, investment, etc.); involvement in standardisation processes (role, quality of engagement and impact); number and impact of media publications and appearances	**capital** Measurable outcomes: value of financial investment in projects; value of IP or in-kind investment in project; impact of project promotion (within the network, in policy or financial arena and in the media); success of the backed projects (project outcomes as in the box above)

Chapter 6: The Ten Million Euro Question: How Do Innovation Intermediaries Support Smart Specialization?

Introduction

The European Union's *National/Regional Innovation Strategies for Smart Specialization* policy (European Commission, 2014), which emerged from regional innovation systems insights in economic development (DG Research Expert Group on Constructing Regional Advantage, 2006), is currently being integrated into a broader innovation policy context. The conceptual salience of geographically and sectorally bound public policy interventions to stimulate the growth of new business activity and complementary diversification of innovation is seen as an important pathway to attaining regional competitive advantage through "smart" prioritization of investment (Camagni & Capello, 2013; Asheim, 2019). The implementation of smart specialization strategy (S3) policy in practice is proposed to primarily center on an "entrepreneurial discovery" approach to identifying opportunities for regional economic development (Hausmann & Rodrik, 2003; David, Foray, & Hall, 2013), which is partially in contrast to the more stakeholder-driven economic analysis and geographical prioritization associated with the previously established economic policies based on constructing regional advantage (Barca, McCann, & Rodríguez-Pose, 2012; Vanthillo & Verhetsel, 2012; Boschma, 2013). However, the implications of various contextual factors of either of the two S3 approaches to geo-sectoral innovation policy development on its operationalization is currently under-studied, especially with respect to on-the-ground implementation through various organizations.

In particular, though some research in the role of institutions[28] to set and govern the S3 policy has been carried out (McCann & Ortega-Argilés, 2014; Rodríguez-Pose, di Cataldo, & Rainoldi,

[28] RIS and S3 literature, as well as innovation studies more broadly, mainly define "institutions" as a mix of formal and informal social structures (Rodríguez-Pose, 2013), which sometimes obscures the differences between intangible "sets of common habits, routines, established practices, rules, or laws" and their manifestation through "formal structures with an explicit purpose" (Edquist & Johnson,

2014; Grillitsch, 2016; Morgan, 2017), less is being said about the on-the-ground deployment of interventions delivering S3 operationalization, which is a key capacity required, and organizations that deliver them (Karo & Kattel, 2016). Specifically, S3 literature is almost entirely devoid of mention of innovation intermediaries, seen by many innovation systems' analysts as key vehicles to deliver "institutionalized learning", which is at the very core of RIS conceptualization (Cooke, Gomez Uranga, & Etxebarria, 1997). Moreover, innovation intermediaries are currently the subject of extensive analysis and debates in the broader economic development literature (Katzy, Turgut, Holzmann, & Sailer, 2013; Nilsson & Sia-Ljungström, 2013; Kivimaa, 2014; Kokshagina, Le Masson, Kazakci, & Bories, 2015; Mgumia, Mattee, & Kundi, 2015; Kerry & Danson, 2016; Lukkarinen et al., 2018; Vidmar, 2018). Hence, a critical gap has emerged in understanding how innovation intermediaries are deployed to support S3 policy. This is especially problematic with the increasing awareness that the challenges for S3 policy are now predominantly in its implementation, which could be alleviated by capacity building through policy interventions (Kroll, 2019). Hence, using the state-of-the-art understanding of innovation intermediation in order to study its current use, and develop proposals for its improvement, within the S3 context is a vital advance in supporting further S3 policy-making.

To that aim, this paper draws upon two carefully selected case studies of two different instances of innovation intermediation, supported by significant direct public investment, in two different yet comparable geopolitical contexts. The rationale behind this work is to explore the different mechanisms used to deliver smart specialization strategy-type policy through innovation intermediation. The interventions examined focus on supporting the economic development of high-tech (New) Space industry in regions that were previously peripheral in this domain, namely in Slovenia and Scotland. Though the geographical conditions in the two countries are somewhat similar, the (historical) socio-economic and political context is not. This led to different prioritization in government investment in the development of this industry, responding not only to the existing economic and research activities and infrastructure, but also to innovation policy path-dependency related to socio-political frameworks (Farole, Rodríguez-Pose, & Storper, 2010).

1997). For clarity, the term "institutions" is used here as in the cited texts, whilst "organizations" will be used in this paper when specifically referring to the actors.

On one hand, in Slovenia, a 10 million euro investment (supported by the EU structural funds) led to the creation of the Centre of Excellence (CoE) Vesolje-SI (Space-SI), a university-led applied research program, in 2009, and on the other hand, in Scotland, a 10.7 million pound UK government investment in 2013 funded the development of the Higgs Centre for Innovation, a business incubator and innovation facility. Though the development of both of these innovation intermediation projects is still ongoing, their inception, implementation, and positioning illuminate a key challenge in direct intervention in an economic sector – whether to focus on research and development (R&D; i.e., creating new products or services) or business development (BD; i.e., creating and accelerating new firms). Understanding these different approaches better will help develop more coherent innovation policy positions on smart specialization strategies since it involves critically examining the emerging "policy mixes"

> *"[…] by focusing much more effort on understanding how implementation, experimentation and adaptive learning affect the impacts of policy interventions driven by real goals." (Flanagan & Uyarra, 2016, p. 185)*

Deploying a recently developed innovation intermediation model (Vidmar, 2018), this paper examines the differentiation in adopted mechanisms between the two cases depending on the (politically) defined intermediation focus. Furthermore, by looking at the set-up of the intermediaries, their primary activities, and target users, the proposed model was developed further by exposing a key systematic combination of different classes of interventions within the overall distinction of R&D and BD support foci. Finally, the societal and political environment leading to the establishment of these two centers is briefly examined and discussed in the context of a divergent implementation of innovation policy, including smart specialization, and its potential pitfalls.

Defining and Implementing Geo-Sectoral Innovation Policy: The Role of Innovation Intermediaries

Innovation Policy in EU and Smart Specialization Strategy (S3)

Smart Specialization Strategy (S3) has emerged as a flagship (European) policy framework linking economic geography research with innovation and entrepreneurial (eco)systems literature (McCann & Ortega-Argilés, 2015). The aim of S3 is to stimulate economic development by focusing investment across different regions into specific and distinct opportunities and thus establishing a regional competitive advantage, both within common market frameworks (such as EU) as well as in global competition (OECD, 2013). This focusing is intended to establish economic actors with a “related variety” of products and services, or industry “clusters”, which are supported by a (local/regional) network of stakeholders, including research organizations, investors, business and infrastructure developers, public sector/government, etc. (David et al., 2013). The main premise is for those “smart specializations” to emerge organically/bottom-up, with clear policy support, once key opportunities have been identified and “nominated” (Foray & Goenaga, 2013).

The latter, however, is easier said than done and represents a very contentious issue. Critique has so far focused primarily on the perceived overreliance on “industrial renewal” within existing regional innovation capabilities, which may be preventing the S3 policy to have real transformative effects (Capello & Kroll, 2016). The main two challenges here are, on one hand, how smart specialization opportunities can be identified, and on the other hand, what (policy) intervention in the sector is appropriate (Foray & Goenaga, 2013). This paper’s premise is that these two issues are very closely linked and that the context and use of the identification process critically define the shape and scope of the final intervention (Hausmann & Rodrik, 2003; Boschma, 2013; Grillitsch, 2016). Crucially, though many tools for identification are shared across the common policy arena (in our case the EU), the path-dependency (based on past ideological/political commitments) critically co-shapes their use and leads to a very different set of policy mixes, interventions, and outcomes.

In particular, innovation policy’s path-dependency leads to different design of S3 policy mixes through contextual factors (Bodas Freitas & von Tunzelmann, 2008; Asheim, 2013; Valdaliso, Magro, Navarro, Aranguren, & Wilson, 2014). One of the critical differences noted is between the “vision-driven” innovation policy-making in comparison to a more “analysis-driven” approach (Polverari, 2016). This corresponds to the consequent difference between building the S3 policy process around the more competitive entrepreneurial discovery of niche specializations or the more stakeholder-driven economic development perspectives on establishing regional advantage (Boschma, 2013). These two approaches crucially also demonstrate a split between respective policy-making objectives of creating new opportunities (Foray & Goenaga, 2013) or addressing systemic failures (Klein Woolthuis, Lankhuizen, & Gilsing, 2005; Seidel, Müller, Köcker, & Filho, 2013). Moving forward, Boschma

(2013) suggests a balancing between these two approaches, built around the inclusion of local stakeholders, and which

> *"[…] should focus on how to enhance true economic renewal, not to pick winners and back them, not to secure local vested interests, and not to make strong local industries stronger."* (Boschma, 2013, p. 12)

Here, S3 literature has not engaged much with the role of innovation intermediaries as organizations tasked with the on-the-ground implementation of innovation policy in many governmental and non-governmental innovation policy contexts. Given their critical role in emergent innovation systems, the understanding of their contribution to S3 implementation may be vital.

In order to be able to study these interventions, including how their roles can possibly transcend the binary divide between entrepreneurial vision and analytical construction of competitive advantage in a systematic, structured, and detailed manner, we adopt two key framings. Firstly, this paper limits its study to look exclusively at the delivery of (government) innovation policy through the establishment of innovation intermediaries and their activities. Secondly, we adopt a comprehensive innovation intermediaries' interventions framework as a central analytical tool to ensure consistency across the two case studies. The focus on innovation intermediaries has emerged due to their bridging role between (policy) intentions and (economic) activities, in particular when looking at regional economic development and the pivotal role support for SMEs plays in it (OECD, 2004; Wilson, 2007; Lee, Park, Yoon, & Park, 2010; Doh & Kim, 2014). The latter two are also the guiding principles behind the S3 framework.

Innovation Intermediaries' Interventions Classification

The classification and typology of innovation intermediaries' interventions outlined below were devised from a detailed review of innovation intermediaries literature, in particular periodic systemic reviews (Howells, 2006; Dalziel, 2010; Kilelu, Klerkx, Leeuwis, & Hall, 2011; Nilsson & Sia-Ljungström, 2013; Kivimaa, 2014; Kim, 2015; Lukkarinen et al., 2018), and combines empirical and theoretical insights to summarize the key policy frameworks and operational factors behind the interventions available to support innovation (Vidmar, 2018). The categorization, sub-categorization, and qualification of the various available classes of mechanisms correspond to the level of the development of the sector and firms and organizations within, as well as demonstrate their dependency on certain systemic socio-economic factors. These prototypological drivers were identified as being related to levels of investment and involvement, the strength of vision/mandate, and soft leadership embedded in the intermediaries' programs.

The classification within the scheme (see Table 12) is constructed using two overarching categories of intervention mechanisms, resources provision and deployment of activities, as related to the varying focus of interventions from more broad and systemic (such as investments in resources) to more targeted and specific (such as direct activities to shape a particular vision for development). These categories are split into subcategories of infrastructure, tools, framing, and project, differentiating those with more hands-on types of interventions (such as engaging in projects and developing infrastructure) and those delivered in more hands-off roles (such as sector framing and providing tools for innovation). On the subcategories level, the classification is further split by intervention qualifiers of being either more "physical" or more "social" in character. These overarching qualifiers enable the intermediaries to distinguish between deployment of "hard" and "soft" assets, such as buildings and equipment on one hand, and social capital and thought leadership on the other.

This classification is underpinned by the understanding that most mechanisms available are critically related to the wider system, which is subject to conditions within the target sector as well as in the immediate geographical area in which the innovation support program is executed (Martin & Scott, 2000; Hannon, Skea, & Rhodes, 2014). When deploying any analysis of suitable innovation support mechanisms, geographical and sectoral boundaries need to be taken into consideration. In particular, based on extensive analysis of key typological systematizations (Klerkx & Leeuwis, 2008; Kilelu et al., 2011; Colombo, Dell'Era, & Frattini, 2015; Kim, 2015), the overarching aims inbuilt into various mechanisms were identified as roughly four-fold: to remove barriers for innovation by providing resources and action to address bottlenecks and challenges; to proactively create conditions encouraging innovation, with the stimulus, promotion, and investment; to create purchase in the innovation, especially by assisting in the development of markets (often external to the sector); and to enact a particular vision for the future of the (economic) activity in a sector (Vidmar, 2018). This roles typology is cross-referenced with the classification (see Table 12). In most cases examined so far, the focus was either on infrastructural investments or specific trendsetting and project work (most usually associated with early stages of an emerging sector/technology) or on more hands-off activities such as providing spaces and incentives for defining trends and easing key skills and equipment shortages (associated with development of commercialization pathways and R&D consolidation of later stages of development).

However, other analytical prioritizations for understanding the deployment of combinations of the classes of intervention mechanisms are possible. In particular, building on a systematic review of literature, Dalziel (2010) exposed the major difference between "inter-organizational networking activities" and "technology development and related activities". These two categories point to an (at least analytical) split between the systemic (networked) innovation intermediation support (often characterized by the term "brokerage") and more direct processual involvement in new product development. Going one step further, the differentiation between the inter-organizational networking and the enabling, supporting, or delivering of specific projects corresponds roughly with the in-firm activities of business development (BD) and research and development (R&D), respectively. Such a differentiation points to the possibility of a significantly divergent approach to delivering innovation intermediation resources and activities, which could be problematic for achieving robust and sustainable policy impact.

Using this framework to analyze two innovation intermediaries' interventions within a similar parameter space (the same sector/technological domain, similar level of investment, similar position within the innovation policy context, etc.), yet in two different geographical, political, and socio-economic contexts will enable an analytical assessment as to which factors influence the potentially divergent application of intervention mechanisms. The main research question is: how do the two different approaches to S3-type policy implementation, i.e., niche specialization versus regional advantage, lead to divergent on-the-ground innovation intermediaries' interventions and what are the contextual factors in this process as well as its implications? Such understanding can significantly assist in theorizing opportunities and pitfalls in S3 policy design and implementation, in particular as related to the role of innovation intermediaries.

<table>
<tr><th colspan="4">Innovation intermediaries’ interventions classification</th><th colspan="4">Prototypological drivers</th><th colspan="4">Typology of innovation intermediaries’ roles</th><th colspan="2">In-firm activities</th></tr>
<tr><th colspan="3">Categories, subcategories, and qualifiers deployed in classification</th><th>Interventions classification</th><th>Close involvement</th><th>Systemic investment</th><th>Strong mandate</th><th>Soft leadership</th><th>Remove barriers</th><th>Encourage innovation</th><th>Create purchase</th><th>Enact a particular vision</th><th>R&D</th><th>BD</th></tr>
<tr><td rowspan="4">Resources
Provision of infrastructure and tools for use by innovation stakeholders</td><td rowspan="2">Infrastructure
Provision of system-level resources</td><td>Physical</td><td><u>Space</u>
Networked provision of physical space for use by stakeholders</td><td rowspan="2">X</td><td rowspan="2">X</td><td rowspan="4"></td><td rowspan="2"></td><td></td><td>X</td><td></td><td></td><td></td><td>X</td></tr>
<tr><td>Social</td><td><u>Knowledge</u>
Systemic provision of knowledge (IP) for deployment in innovation processes</td><td></td><td></td><td></td><td>X</td><td>X</td><td></td></tr>
<tr><td rowspan="2">Tools
Provision of specific deployable resources</td><td>Physical</td><td><u>Equipment</u>
Provision of specialist or otherwise inaccessible tools and devices</td><td rowspan="2"></td><td rowspan="2">X</td><td rowspan="2">X</td><td>X</td><td></td><td></td><td></td><td>X</td><td></td></tr>
<tr><td>Social</td><td><u>Skills</u>
Provision of expertise, advice, and workforce</td><td></td><td>X</td><td></td><td></td><td>X</td><td>X</td></tr>
<tr><td rowspan="4">Activities
Active engagement in defining and developing future innovation products</td><td rowspan="2">Framing
Activities deployed to facilitate wider system development</td><td>Physical</td><td><u>Interaction</u>
Active development of opportunities for engagement of stakeholders</td><td rowspan="2"></td><td rowspan="4"></td><td rowspan="2">X</td><td rowspan="2">X</td><td></td><td></td><td>X</td><td></td><td></td><td>X</td></tr>
<tr><td>Social</td><td><u>Translation</u>
Active brokerage between stakeholders and identifying development trends</td><td></td><td></td><td>X</td><td></td><td></td><td>X</td></tr>
<tr><td rowspan="2">Project
Specific innovation projects to interlink stakeholders and further specific innovation pathways</td><td>Physical</td><td><u>Work</u>
Active engagement with innovation projects and investment of staff effort</td><td rowspan="2">X</td><td rowspan="2">X</td><td rowspan="2"></td><td></td><td></td><td></td><td>X</td><td>X</td><td></td></tr>
<tr><td>Social</td><td><u>Capital</u>
Active deployment of resources (financial or otherwise) to an innovation project</td><td>X</td><td></td><td></td><td></td><td></td><td>X</td></tr>
</table>

Table 12 - Cross-Referenced Innovation Intermediaries' Interventions Classification with Prototypological Drivers, Typology of Roles of Innovation Intermediation, and In-Firm Activities.

Methodology

The innovation intermediation model presented above was analytically deployed using comparative case studies approach (Yin, 2009). Two critical instances of innovation intermediation are examined in a geo-sectoral innovation policy context, whereby path-dependency on contextual factors led to different approaches to selection and deployment of interventions. These differences are studied descriptively to establish a correlation with their underlying reasons as well as explore their potential implications (Farole et al., 2010). Given the relatively small size of the two selected geo-sectoral contexts and consequently small sample size, qualitative analytical generalization with a pre-determined framework is more reliable than statistical methods (Hartley, 2004).

The research design combines a mixture of secondary data analysis of policy documents and websites (Bowen, 2009), and primary data from longitudinal participatory observation ethnography through events, conferences, and visiting the organizations' workplaces (Darrouzet, Wild, & Wilkinson, 2009). This was complemented with primary interview and survey data, collected by directly speaking to the staff of the two selected cases (Bryman, 2016). Though only two interviews and two formal surveys were used, given the relatively small sizes of both innovation intermediaries' teams (they both have only three core members) and their close cooperation in filling out the survey questionnaire in particular, the results from interviewing/surveying two members of staff at each organization can be treated as highly reliable, even though the sample size is relatively small.

The document analysis and participatory ethnographic data led to the overarching case studies' descriptions and key identified concepts and trends, whilst direct primary empirical data were used to quantify the key points of divergence between the two cases. On one hand, the interviews were designed to explore the innovation networks of the two intermediaries, asking interviewees to list all partners they work with and subsequently structure those partners according to geographic proximity and basic differentiation between public and private organizations. On the other hand, the surveys assessed the two innovation intermediaries' intervention priorities and the contextual reasons for those – in particular a Likert-scale ranking of their provisions with respect to each of the intervention classes (on a scale of 1 to 5) and an overall priority ranking across all intervention classes as well as perceived sectoral needs (in order from 1 to 8) – as well as information about the programs' overall aims and the reasons for them.

Specifically, the secondary and ethnographic data were used to present a brief outline of the set-up of the two innovation intermediaries and their activities so far, including contextualizing some of their challenges presented in the discussion. In addition, data collected through the interviews were used to draw up the ego-centric social network analysis plots for each of the studied intermediaries (Crossley *et al.*, 2015), whilst the structured survey data helped frame the analysis of the intervention prioritization within the case study analysis.

S3 – Slovenia, Scotland, and Space: Two New Players in a New Industry

Under the European Union cohesion funding program, which is one of the cornerstones of S3 implementation, Slovenia and Scotland are considered equally as NUTS level 1 regions[29], though Slovenia is an independent country, while Scotland is a country within the union of the United Kingdom (UK), though with significant political devolution. In the "Europe of Regions" vision (Jolly, 2006) for the EU future development[30], the two countries would eventually achieve relative parity of political status and establish primarily endogenous administrative, economic, and social framework conditions, with weaker referential relationship to other institutional levels (in particular nation-states). The two countries are similar in many key parameters[31] yet diverge significantly in parts of the socio-economic,

[29] Following European Union's Nomenclature of Units for Territorial Statistics (NUTS) level 1 (top-level) regional definition framework (Regulation [EC] No. 1059/2003 of the European Parliament and of the Council of 26 May 2003, 2018).

[30] On top of the vision of European regionalization being politically challenged in recent years, there is an added point of divergence with possible UK departure from the EU, i.e., Brexit. This paper will assume, however, that the framework conditions during which the intermediaries in question were being developed have to a large extent hinged upon a continuous membership of EU.

[31] For example, using Regional Innovation Scoreboard (https://ec.europa.eu/growth/industry/innovation/facts-figures/regional_en; last data available for 2017) summative assessment and comparing aggregated NUTS 2 level data for Slovenia (as level 1 data are not available) and NUTS level 1 data for Scotland, the two countries are in the same category of "strong innovator" though Scotland is in the top band (strong plus), whilst Western Slovenia (including the capital) is considered a "strong innovator" and Eastern Slovenia is in the "moderate plus innovator" category. Key similarities are strong tertiary education and SME collaborations and weak EPO patent applications, whilst critical differences are in trademark and design applications (strong in Slovenia) and strength of scientific publications (stronger in Scotland, though both above EU average). The Regional Innovation Index 2017 for the two regions are 0.52 for Scotland and 0.44 for Slovenia.

political, and cultural landscape[32]. In recent years, both countries being part of the EU led to a certain degree of legislative homogenization including in aspects of innovation policy (such as S3), though through persistent socio-economic differences significant divergence in on-the-ground implementation has emerged, which is interesting in exposing contextual elements in applying EU-wide S3 policy.

To remove, as much as possible, the variables between technological domains and sectoral activities, a single sector was picked to be examined, i.e., the New Space sector, which is present and relatively new to both countries. The specific suitability of the New Space sector for this study is further related to three key features:

- The sector's recent emergence, significant growth, and future potential, as well as (global) recognition of competitive advantage
- Government/policy-makers' recognition of its importance, including, but not limited to, the establishment of innovation intermediaries
- Its underlying importance for the headline S3 priorities, even though it does not feature strongly in the policy itself

The latter criteria are particularly interesting as often (too) little attention has been paid so far to the enabling (more upstream) sectors/industries supporting the development of the (generally) more downstream/applied S3 priorities. The emergence and development of these enabling technologies also pre-date the full roll-out of the S3 framework but are

---

[32] Slovenia and Scotland share aspects of historical and contemporary development over the past 200 years, for instance by being part of supra-national political unions (in Slovenia's case these constitutional ties were with the Habsburg Monarchy, the Austro-Hungarian Empire, the Kingdom of Yugoslavia and the Socialist Federative Republic of Yugoslavia; whilst Scotland is part of the United Kingdom, which underwent a process of division (island of Ireland) and more recently devolution (Wales and Scotland). They also both contain diverse geography (in particular remote mountainous areas and densely concentrated lowlands). Both countries are also politically divided, in Slovenia along partisan lines, whilst in Scotland additionally with respect to position on statehood (independence from UK). Both having an ageing population and having seen much of traditionally strong manufacturing industry deplete, in the 1980s in Scotland and 1990s in Slovenia, they are both now economically based around service industries (centred on their respective capital cities) and agriculture and tourism in the periphery. The differences are predominantly socio-political, due to legacies of the 1990s' transition from socialist economics in the post-second-world-war era in Slovenia in contrast to neo-liberal industrial reforms led by the conservative UK government in the 1980s. There are also broad cultural differences in the educational/intellectual system and overall public service, with the Central-European administration-heavy system inherited in Slovenia in contrast to the more entrepreneurial Anglo-American framework present in Scotland. Through economic and social globalization, these differences are slowly being eroded, which is reinforced by the adoption of the neo-liberal economic and social development model by the EU.

crucially tied into its origins of the geographically-bound sectoral opportunity focus and the emergence of specific lead sectors/technology domains.

Smart Specialization in Slovenia and Scotland

The development of S3 headline priorities in Slovenia and Scotland has a long and varied (as well as temporally different) historical evolution, very different entrepreneurial and innovation landscape, and very different policy instruments. For instance, as evidenced in Scotland (Reid & Maroulis, 2017) and even more so in Slovenia (Reid & Stanovnik, 2013), the initial S3 policy roll-out was not applied systematically, heavily depended on prior policy targets and often lacked in cohesion and concrete implementation mechanisms, which were otherwise present in other aspects of (regional) economic development policy (especially in longstanding sectoral priority areas). On one hand, some of these initial issues with S3 policy implementation have been addressed and Slovenia, in particular, is being presented as a case of good practice in adopting the entrepreneurial discovery process that encourages stakeholder ownership of S3 priorities and their governance (Gianelle, Kyriakou, Cohen, & Przeor, 2016; Karo, Kattel, & Cepilovs, 2017; Wostner, 2017). On the other hand, the more complex Scottish constitutional position with respect to the UK means that a mixture of regional and national innovation policies apply centered around multi-level “industrial strategies”, creating a significantly stakeholder-driven policy framework (Mastroeni, Omidvar, Rosiello, Tait, & Wield, 2017). This critical difference makes the two countries prime examples for analyzing the organizational implementation of geo-sectoral innovation policy, noting its pre-S3 origins and path-dependencies.

The “official” S3 priorities in Slovenia and Scotland directly overlap somewhat (as highlighted in italics), as in Slovenia they are: smart cities and communities, smart buildings and homes, networks for transition into circular economy, *sustainable food production*, *sustainable tourism*, factories of the future, *health-medicine*, mobility, and development of materials as products (Republic of Slovenia, 2017); and in Scotland: creative industries, energy, financial services, *food and drink*, *life sciences,* and *tourism* (The Scottish Government, 2015). Additionally, the “smart infrastructure” strand in Slovenia significantly overlaps with parts of the “energy” priority in Scotland (smart grid, renewables, etc.), as well as “circular economy” and “advanced manufacturing” being emphasized in both frameworks.

In contrast, one of the key enabling technologies supporting the identified S3 opportunities[33] has a much more homogenous trajectory between the two countries and is present in the overlapping priority areas, in particular in agri-food and smart infrastructure, as well as in advanced manufacturing/factories. This area combines remote environmental monitoring through the use of space/satellite data for Earth observation and new high added value engineering, including space hardware – i.e., the New Space. This sector emerged in the mid-2000s in both cases (and globally), though in Scotland it evolved from entrepreneurial activities and organic knowledge spill-over only attracting more substantial policy investment later (after 2010), whilst in Slovenia, the innovation intermediation interventions were deployed to kick-start the sector earlier (in 2009) and are only now engaging with the wider entrepreneurial landscape (since 2015). This demonstrates a very different path-dependency for intervention mechanisms, which are in more detail examined below, based on two flagship case studies of the two largest innovation intermediation investments, the Slovenian center Space-SI (2009) and the Scottish Higgs Centre for Innovation (2013).

The (New) Space Sector

Analysis of the space sector is ordinarily split into two main areas: upstream (hardware and data acquisition) and downstream (data processing and applications) (OECD, 2007b, 2011, 2014). There are three key types of technologies, and consequently, products/services involved: Earth observation, (GIS) navigation, and telecommunications and broadcasting (Satellite Applications Catapult, 2014; Space IGS, 2014). The sector's historical development is in its 3rd phase – after the initial state monopoly (1st phase), the technology was commercialized by large multinational corporations (2nd phase), and is now being democratized through innovation and entrepreneurship as the previously complex and expensive hardware becomes smaller, more standardized, and cheaper (Space IGS, 2011). This is sometimes referred to as the transition from "classical" towards "New Space" (Adlen, 2011).

[33] Space as a key enabling technology for S3 opportunities has also been identified in many other regions, for instance, Lazio (Lombardi, 2016).

This is particularly visible as:

- **Increased commercial tendering for government programs**, in particular with regards to "services" such as launch capability, operations management, etc. Though the corporate monopolies are still dominant (in the "classical market"), disruptive technologies are making this area much more competitive – with entrants such as SpaceX (working on reusable launch rockets) and Virgin Galactic (space tourism). These are not really present (yet) in either Scotland or Slovenia as they develop around strong governmental space policy, which neither country has[34].
- **Establishment of the smaller satellites market** (<500 kg), operating outside the traditional paradigms (cheap, rapidly-prototyped, and mass-produced products based on consumer electronics and composite materials). Scottish SMEs Clyde Space and Alba Orbital are significant players in the smaller (nano- and pico-) end of this emerging market and R&D in this area is also present in Slovenia (e.g., NEMO-HD and TRIsat satellite projects), though mainly in intermediaries (Space-SI) and research organizations (University of Maribor), respectively.
- **Significant expansion of space data market,** driven by the high-tech tail end of the development of data science and global connectivity, creating data storage, analysis, and access to information on an unprecedented scale; being extensively supported by open data policies of major Earth observation programs, in particular the EU-funded Copernicus program (Berger, Moreno, Johannessen, Levelt, & Hanssen, 2012) and US National Oceanic and Atmospheric Administration's Landsat (Woodcock *et al.*, 2008). Slovenian and Scottish SMEs have been recognized as competitive leaders on the European level[35].

The Case Studies' Context

Slovenia has a long history of involvement with astronomy, space science, and space exploration, from Jozef Stefan's research in black body radiation to space travel pioneers like

[34] The UK in particular has developed space policy as part of its science and industrial/innovation policies rather than a full-blown space program seen in most other large space "powers" (Vidmar, 2020).

[35] For instance, Slovenian SME Synergise and Scottish SME Astrosat both won the European Space Agency's Copernicus Masters competition for best EO data application (ESA, 2019a).

Herman Potocnik Noordung, who was at the heart of the 1920s' "first shot at space". More recently, Slovenian-born scientists and engineers were involved in several key international projects, though it is only in the past couple of decades that globally important research and applications have been developed in Slovenia itself. In addition to world-leading research being conducted at Slovenian universities, for instance in space medicine, Slovenian companies supply state-of-the-art components and materials to the global space industry. Though the number of spin-offs and SMEs is still relatively low (10–15 in 2018), most of them are strong exporters and internationally competitive in their niche areas (Bušljeta, 2019; Uranjek, 2019).

Furthermore, many interdisciplinary centers and groups have been established within the academia in the past decades to examine opportunities to develop independent capabilities and space assets, in particular in tracking and ground stations, small satellites and components, and data analysis and applications. Slovenia is also home to initiatives in the field of contextualizing space science and technology through art and humanities, both in research and practice, with an extensive program of activities supported by key international space agencies and players, including NASA, ESA, and Roscosmos (Russian Space Agency) (Leach, 2014). Though still without a national space agency or a state-backed space program, since 2016 Slovenia is an associate member state of ESA (European Space Agency).

Scotland, too, has a long and rich history of astronomy and space science, with notable people and institutions leading key global developments for centuries. In more recent times, the activities particularly relevant for (New) Space industry are linked to the commercialization of satellite broadcasting and telecommunication technologies, where Scotland has played a significant role within the broader UK effort (i.e., BskyB, Inmarsat, etc.). Furthermore, over the past 5–10 years, Scotland has become widely known around the world as a "New Space hub" with "Space Glen" and "Agile Space" brands, and with leading upstream and downstream New Space primes being established (Scottish Business Insider, 2018). This developed initially (in the 2000s) from three leading clusters of research and economic activity in Glasgow (hardware), Dundee (electronics), and Edinburgh (data analytics) and in total some 20–25 SMEs (in 2018). Most of these firms are export-oriented and internationally competitive (Macdonald, 2017, 2019).

These SMEs benefited from a long-standing historical legacy of science, engineering, and venture creation in Scotland and in the UK, as well as regional and national investment in science, R&D, and innovation, as part of the broader (regional) economic development vision. For instance, (aero)space is a key target sector for Scottish Enterprise, the regional economic development agency, roughly following a UK policy to attract a 10 percent global market share by 2030 (Space IGS, 2011), of which 10 percent (or 1 percent of global) should be in Scotland (London Economics, 2015a). This work expanded significantly in the past decade, from participating in global aerospace B2B supply chains to the sector achieving relative maturity, by consolidating an entire New Space value chain within Scotland, such as in the attempts to institutionalize the regional ecosystem with the establishment of the (industry-led consortium) Agile Space Group in early 2017 (Agile Space Group, 2017).

From Policy to Practice: Innovation Intermediaries and Interventions

We now turn to the two case studies of innovation intermediation within Slovenia and Scotland; in particular, the way in which the two intermediaries were set up, what kind of objectives were proposed, and what kind of interventions were planned/delivered, including briefly examining who their beneficiaries were. This has been drawn from digital and physical document analysis (websites [see Figure 16 for illustration], brochures, leaflets, talks/presentations, records of public statements, etc.) and primary data collection (interviews, discussions, participant observations, etc.). The resulting analysis has also been validated by the relevant representatives of the centers in an ongoing process of open exchange of data, ideas, and findings/conclusions.

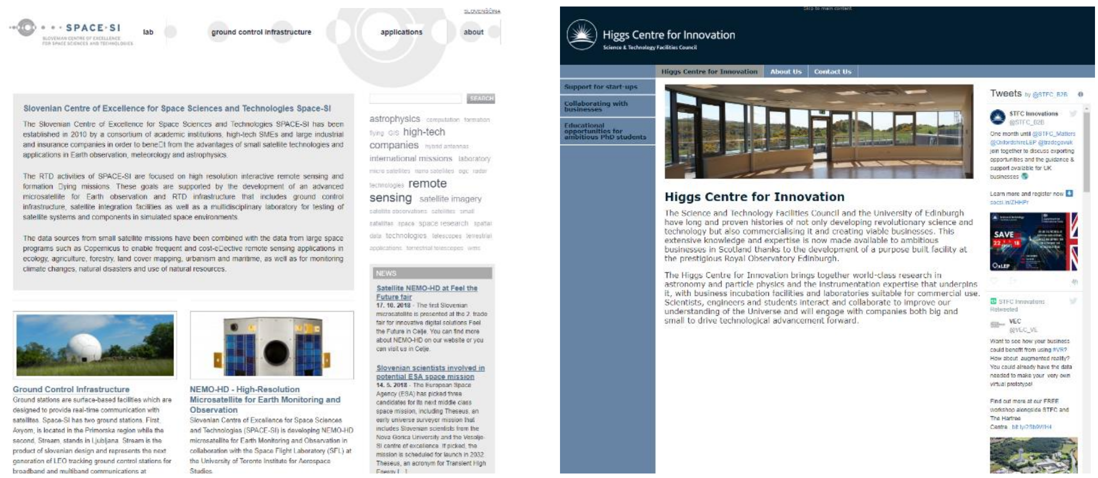


Figure 16 - Space-SI and Higgs Centre for Innovation Website Captures with Headline Information and Current News about the Work at the Two Centres

A Cradle of Applied Research (Slovenia): Centre of Excellence Space-SI

The Centre of Excellence (CoE) Vesolje-SI or Space-SI was established in 2009 by a consortium of 11 partners (5 academic, 5 industry, and 1 lead-user) responding to a call by the Slovenian Ministry for Economic Affairs, which led to the establishment of eight different sectoral CoEs, each backed by a 10 million euro investment (85 percent from EU Regional Development Fund) over the first four years of operation (2009–2013). Beyond that, the CoEs were expected to operate the same regime of research and development without governmental support for another five years.

In addition to engaging with policy-makers and other stakeholders in shaping the Slovenian response to various developments and trends in the European and global space industry (i.e., "New Space" and "Open Space"), the applied research nature of the center meant it formed three lead groups of work/projects, covering the whole (New) Space sector value chain:

1. **Satellite development and testing environment** (upstream), in particular by developing the indigenous capability for satellite design and testing, whilst integrating into a global network of upstream space developers, in particular by working with lead partners from Canada, and symbolically putting Slovenia on the space countries map.
2. **Mobile ground station and signal transmitting systems development** (midstream), working, in particular, to bring together and activate a host of Slovenian businesses with various technological capabilities, but without prior interest or involvement in space industry, also leading to a market pole-position.
3. **Space data applications** (downstream), specifically by working with already well-established networks and public and private actors within Slovenia (in particular ZRC-SAZU) and establishing a public profile for space data applications.

In particular, in the case of the ground station, a surveyed member of staff remarked:

> *"With revolutionary advances in the small satellite sector, especially related to the emerging mega constellations, SPACE-SI saw a need to design the ground station that will be able to track a large number of low powered satellites, many of them cube-sats, that will produce huge amounts of fragmentally generated data." (Emphasis added.)*

In doing so, Space-SI pursued at once three complementary models of innovation, with:

a) Knowledge absorption and technology transfer from global networks
b) Development of a related variety cluster of actors
c) Bottom-up open innovation with a broad stakeholder base

Such broad value chain engagement and tri-partite approach to innovation are highly unusual in a single small-to-medium sized (public) organization and are more akin the behavior of either multinational corporations or public agencies (with much broader remits and deeper budgets).

At the moment, the initial (pre-prescribed) phase of the CoE's development is nearing completion, and the center is looking at ways in which it can most effectively continue and expand its activities, in particular in terms of commercialization of products, which was so far not permitted under the terms of the EU/government investment. In line with the observation above, the two competing conceptualizations of the future set-up and modus operandi are:

1. Spinning out a (group of) SMEs, following similar models from abroad (cases to note are Silicon Valley and Scottish Agile Space model), or
2. Developing a new "business paradigm" of critical infrastructure R&D and commercialization for the public good (and also learning from experiences of world-leading research centers, such as Surrey Space Centre).

A Business Launchpad (Scotland): Higgs Centre for Innovation

Backed by a 10.7 million pound direct UK government investment administered by the Science and Technology Facilities Council (STFC), one of UK's main funding bodies for natural sciences research, the Higgs Centre for Innovation at the Royal Observatory Edinburgh (ROE) was announced as a new business incubation and innovation facility in 2013. The center was established at the nexus of three contexts: the ROE campus was the only one of the STFC-run national laboratories without such a facility, the UK wanted to celebrate the receipt of the Nobel Prize in Physics by Edinburgh-based Peter Higgs, and the space industry in Scotland and the UK has become a prominent emerging industrial sector. In particular, after its initial emergence in the (late) 2000s on the back of several successful entrepreneurial start-ups and university spin-offs, the budding Scottish New Space sector was identified as a key development area (by both the UK and Scottish government) and found to be lacking access to physical space, as well as more targeted activities to disperse skills.

Hence, the project proposed to create a regional nano-satellite and space data application incubator, closely linked to STFC's UK Astronomical Technology Centre, based at the ROE. According to the aims of the program, the Higgs Centre for Innovation is planned to:

"[…]

- *House and incubate up to 12 high-tech start-up businesses*
- *Support them with a comprehensive package of business training, technical advice, and access to equipment and facilities*
- *Provide PhD students with direct experience of entrepreneurial environments*
- *Offer to SMEs access to specialist labs and test facilities for micro/nano-satellites housed within dedicated clean-rooms"* (STFC, 2015)

This is related to its core mandate to "create new market opportunities", through "enabling start-ups to translate fundamental research into wider commercial impact" by "applying business incubation best practice to big data and space technology" (STFC, 2013). Importantly, the Higgs Centre for Innovation is not a stand-alone project, as it is run in collaboration with the University of Edinburgh (especially its Institute for Astronomy, also based at ROE) and is

"[…] part of the European Space Agency (ESA) BIC UK, CERN BIC, and UK Space Agency (UKSA) BIC networks."* (STFC, 2018)

The main part of the investment included the construction of new offices and laboratories and acquisition of associated equipment. As such, it required a significant financial investment, in this case relying on public funding, which was justified on the basis of a pre-existing emergent ecosystem (including a critical mass of companies) and a significant social capital vested in the STFC (most often built on past track record and/or existing infrastructure). Specifically, this was acknowledged as:

"The new centre will build on the success and proven track record of similar models seen in the STFC ESA and CERN Business Incubation Centres as well as the Innovations Technology Access Centre." (STFC, 2013)

Crucially, due to the significant amount of public funding involved in this program, the steering vision for the center is far more modest, in line with science and innovation policy conceptualization of the state as a "neutral broker" (Egbunike, 2016) providing more general support (Bodas Freitas & von Tunzelmann, 2008). Also of note is the extensive start-up and spin-out focus, engaging with the early-stage innovation process and emerging opportunities and markets, with specific support primarily for commercialization and business development, with secondary roles in knowledge and technology transfer and sectoral integration. The center was completed and opened in May 2018 and has within its first year (as of May 2019) attracted five incubate SMEs and held several industry networking and knowledge dissemination events in its dedicated lecture space.

Discussion: Ten Million Reasons for Specific Design and Application of Interventions?

Clearly, both of the above organizations deliver support in the research and development (R&D) and business development (BD) domains, with the intention to support or establish new commercial opportunities. This is primarily oriented to link academia and regional business ecosystems, with a particular focus on SMEs. However, looking back at the proposed identification of the four main objectives of innovation intermediaries' interventions, a clear divide has emerged between the two studies, in that the Slovenian case is predominantly focusing on enacting a vision, whilst the Scottish one is more focused on enabling innovation. Though these are contingent indicators only, the staff's survey data ranking of their interventions classification, presented in Figure 17, also points to significantly different prioritization of various available types of interventions, i.e., stronger performance on work, knowledge, and skills for Space-SI, whilst the Higgs Centre for Innovation is more focused on space and skills. The ranking contained here is subject to change as operational activities (and related policies) are in a constant state of flux. Using the perspective of the prototypological drivers, both intermediaries are strong in providing "systemic investment", and the Slovenian Space-SI is also enacting a "strong vision/mandate". This set-up of the two intermediaries strongly suggests that the Slovenian Space-SI center is predominantly focused on applied research (or R&D), whilst the Scottish Higgs Centre for Innovation primarily supports business development (BD).

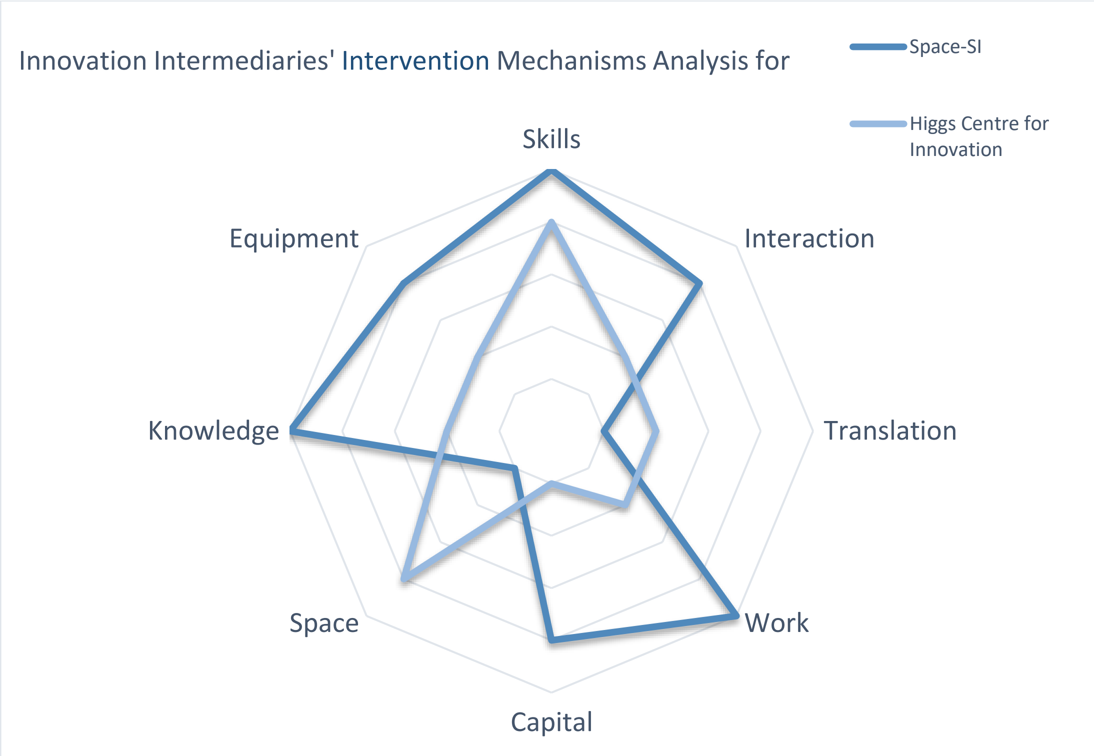


Figure 17 - Analytical Ranking of Key Innovation Intermediaries' Intervention Mechanisms Deployed in the Two Case Studies Using a Likert-Scale-Based Methodology and Source Data from Surveys

This division is also clearly evident when examining the intermediaries' respective ego-centric networks, containing the main organizational partners supporting and participating in the intermediaries' programs. Specifically, as seen in Figure 18. Space-SI's network is dominated by private partners mainly within the city and country of operation (Slovenia), whilst the Higgs Centre for Innovation's network is heavily dominated by public partners, equally distributed in the city (Edinburgh), country/region (Scotland), and state (UK)[36]. This is consistent with the findings from across the wider innovation networks in both countries (Martin, Pahor, & Jaklič, 2015; Vidmar, 2019b). The critical distinction here is beginning to emerge in terms of the organizational set-up, linked to the aims of the two intermediaries'

---

[36] In addition, the associated qualitative data for the Higgs Centre for Innovation point to a particularly strong presence of geographically fluid partners, spanning city-region/country, region/country-state, and state-Europe boundaries by having local presence within the smaller geography, but a wider influence over the bigger one – a good example here is Scottish Enterprise, which has significant offices in the city of Edinburgh and operations across (Central) Scotland.

programs. In the R&D-focused Slovenian case, the focus is on applied projects between the main research organization (University of Ljubljana) and its already established SME partners, which already have established roles within the (business) ecosystem, but they lack concrete new products or services development incentives. Importantly, these private players were also involved in the set-up of the center itself, as mentioned in the survey:

> *"The Slovenian Centre of Excellence for Space Sciences and Technologies SPACE-SI has been established in 2010 by a consortium of academic institutions, high-tech SMEs and large industrial and insurance companies in order to benefit from the advantages of small satellite technologies and applications in Earth observation, meteorology and astrophysics." (Emphasis added.)*

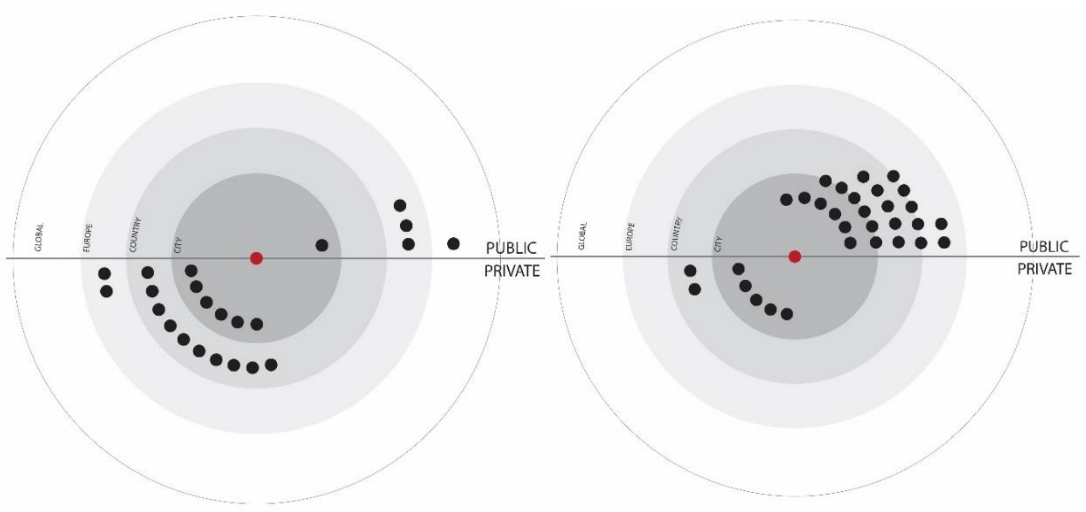


Figure 18 - Ego-Centric Social Network Graphs of the Two Studied Innovation Intermediaries' Networks, Space-SI (left) and Higgs Centre for Innovation (right)

Conversely, in the Scottish case, the impetus is on building business development capabilities, supported by inter-organizational networking and learning, thus the Higgs Centre for Innovation relies more heavily on other intermediaries, research organizations, and funding/development agencies whose resources and capital can be leveraged in this arena. In the survey responses, they mention that:

> *"There was a real block between academic thinking and the commercial world that still needs to be broken down. The programmes we offer are meant to make these easier. [...] To make links between academic*

research and the commercial world. Furthermore, to derisk innovation as both can be challenging for pushing ideas out to a wider market."
(Emphasis added.)

Furthermore, the difference between these two approaches is higlighted when the two intermediaries' priorities are examined in relation to regional sectoral needs, as seen in Figure 19. On one hand, as with provision ranking across all intervention classes, it becomes clear that Space-SI prioritizes the provision of R&D-related interventions (classes of work and knowledge) and the Higgs Centre prioritizes business development support (through facilitating interaction and deploying capital). On the other hand, it seems they recognize that in their respective contexts, there is an opposite need for R&D (work) in Scotland and greater need for BD (capital) in Slovenia, and they point to lack of funding as a critical unresolved issue. Both locales are also lacking interventions to establish translation activities and skills in Slovenia and knowledge in Scotland.

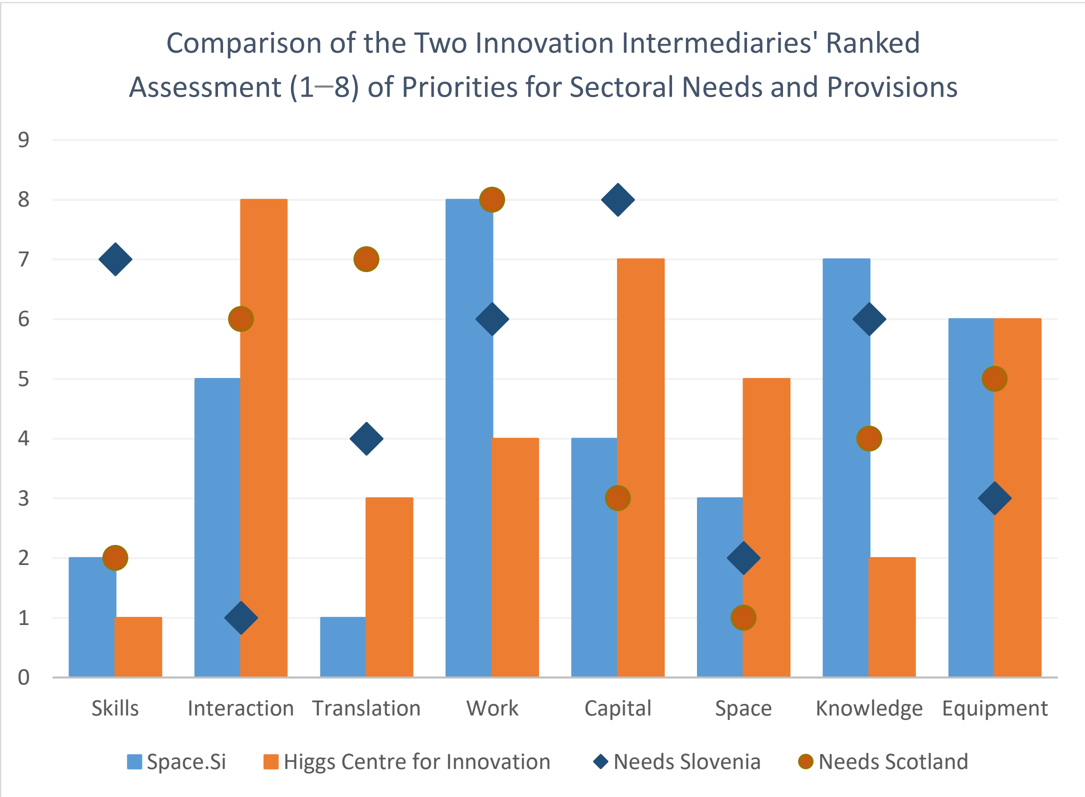


Figure 19 - Regional Sectoral Needs and Provisions Ranking for the Two Cases

Intermediaries' Set-Up: A Question of Politics or Economics?

The analytical findings above clearly point towards a fundamentally different approach to setting up these two intermediaries, as can already be noticed from statements in policy documents proposing their establishment. The summative comparison of the contextual factors and specific observed policy approach features is presented in Table 13. Specifically, Space-SI was set up as a “center of excellence” with a remit to develop projects leading to applied research solutions in niche areas by integrating diverse actors across the science and business community. In contrast, though the Higgs Centre for Innovation is tapping into a similar policy vision in the UK, as its conceptual roots can be traced back to the Eight Great Technologies paper (Willetts, 2013) and the subsequent investment in Knowledge Transfer Networks and the Catapult network, its focus is firmly in providing resources for start-ups and early-stage SMEs (Kerry & Danson, 2016).

Interestingly, the Slovenian investment was developed competitively, through a bidding process via an open call, while the Scottish intervention was designed through closed governmental policy mechanisms with industry input. It is then interesting to observe that in implementation, the stakeholder-driven vs. entrepreneurial discovery approaches are reversed, as the Slovenian approach is steering the sector development by creating innovation supply through R&D project work, while the Scottish one is proposing to satisfy a perceived existing demand for BD on the back of an already established supply of R&D ideas, though these might lack some of the edge achieved through more substantial investment.

This study was unable to explore how much of either approach is based on rhetorical political constructs or evidence-based analysis, which would be a critical addition to further substantiate this dichotomy. However, one interesting observation emerged: given the above split between entrepreneurial discovery-based and stakeholder-driven policy process differentiation, it seems that the demand for intervention (originating from universities) within Slovenia was very present, as manifested in the successful consortium of actors shaping the Space-SI bid, whilst the Scottish entrepreneurial ecosystem had been politically “steered” to further grow economically and created a regional advantage by governmental investment in building the Higgs Centre for Innovation. Both approaches are crucially linked to delivering the program through supporting knowledge and technology development and transfer from academia.

Policy approach / *Contextual factors*[37]	Niche specialization	Regional advantage
Policy ethos	Entrepreneurial discovery	Stakeholder-driveng policy
Critical elements	Policy process, market, competition	Geography, relatedness, ecosystem
Policy action	Facilitating self-discovery	Removing bottlenecks / Stimulating innovation
Case study	***Space-SI (Slovenia)***	***Higgs Centre for Innovation (Scotland)***
Policy set-up process	Competitive negotiation of interests through open bid	Policy design within government agencies
Level of maturity	Low	Intermediate
Lead stakeholders	Academia + business	Government/NGOs + academia
Lead users	Established firms	Start-ups
Main policy principle	"Capitalize on advantage(s)"	"Neutrality"
Intermediaries' intervention prototypological driver	Strong mandate	Systemic investment
Main type of innovation intermediation role	Enacting a vision	Enabling innovation
Main support focus	**R&D**	**BD**
Implementation ethos	"Steering development"	"Satisfying demand"

Table 13 - Comparison of Diverging S3 Implementation and Contextual Factors across the Two Case Studies

"Scouting the Ecosystem": Alignment of Intermediaries' Intervention to Geo-Sectoral Development

Partially, these different visions can be explained as responses to different levels of maturity of the emerging New Space sector in the two contexts at the time of the interventions being implemented, with the Slovenian sector less developed than the Scottish one. However, it is not clear yet that the Slovenian center accelerated the sectoral development more broadly, since operating within a quite significant set of (regulatory) constraints meant that the commercialization efforts within its program are only now emerging fully (Stare, Bucar, & Udovic, 2014). Even as the most restrictive barriers (prohibition of commercial exploitation) expired at the end of 2018, lack of access to capital (public or private) is slowing down BD efforts within Space-SI.

[37] Derived primarily from Boschma (2013) and Asheim (2013).

Conversely, while (economically) more active, it is equally uncertain how competitive the Scottish sector will be in the mid to long term, as the products and services developed there are comparatively less technologically advanced, since applied research investment is structurally less matched to the specialization areas, as it is funded through other mechanisms. Some of the issues with scope and scale of R&D funding are currently being addressed through Challenge Funding and place-based City Deals available through the UK's industrial strategy (HM Government, 2017). However, being first to bring solutions to the market and establishing the Agile Space brand (Vidmar, 2019b, 2020) is ensuring a bigger presence on the global market for Scottish than Slovenian products and services.

Furthermore, the critical question in innovation intermediation intervention is who the users of any given program are (Hyysalo & Stewart, 2008). Looking at the intervention classifications, the primary target users of the Space-SI program are established companies looking for new opportunities and markets, whereas the Higgs Centre for Innovation is aiming to enter into an already forming market in order to support emerging economic actors (i.e., start-ups). Interestingly, the "strong vision" enacted by the Slovenian center is, hence, embedded in an existing system and the "systemic investment" offered by the Scottish intermediary is supporting and promoting new "visions" for the existing sectoral development. This might yet again be related to the existing sectoral composition, for instance, the more research/less mature economic sector in Slovenia and less research/more economically active sector in Scotland; however, it also exposes a policy approach difference between the two cases.

The Fundamentals: Cultural and Political Differences in Approaching "Impact"

Crucially, some of these differences can be explained in more societal terms (Farole et al., 2010) through understanding the policy rationales, goals, and implementation approaches as resulting from interaction and tension between different levels and aspects of policy-making and its participants (Blair, 2002; Flanagan, Uyarra, & Laranja, 2011). In particular, there are clear differences in the political ideology surrounding innovation policy between the two contexts examined in this study. Whilst there is a wide acceptance that supporting innovation is required for continuous and sustainable economic development and growth, the type, level, and mechanisms of policy involvement are considered very differently. In Slovenia, the support is delivered through significant direct investment in the development of specific applications as long as they are predominantly administered within the academia, with commercial applications as a secondary outcome (Bucar, 2015). In the UK, the perceived view is that the innovation support should directly target and involve business interests, with research investment being covered (or not) by separate (science) funding (Edler, Cunningham, Gök, & Shapira, 2013). This is made very clear not only from the two cases presented here but also when examining other intermediaries and interventions, such as incubation facilities, accelerators, and networks (Slovenian universities' technology parks and incubators, UK-wide KTN and Catapult networks, etc.) (Kerry & Danson, 2016; Bučar & Rissola, 2018).

An additional interesting angle here is the diverging definition of scientific "impact" amongst the two contexts, which has a clear economic benefit at its core in the Scottish (UK) one, whilst it is far more flexible and interpretative in the Slovenian case. In particular, BD-type support has been shown to an extent as being more "efficient" (Nishimura & Okamuro, 2011), which is a critical element of the UK/Scottish policy discourse, more than in Slovenia. Such wider policy narratives are significant co-shapers of the systemic integration of innovation policy (and S3 specifically), which may lead to different emphasis across the different environments, including lack of systematic application of EU-wide initiatives (Kroll, 2015; Reid & Maroulis, 2017).

Following other analyses of innovation policy path-dependent trajectories and capacities in comparable contexts (Valdaliso et al., 2014; Karo & Kattel, 2015; Karo & Looga, 2016), one avenue of future research could hypothesize that Scotland has bought into the development of regional competitive advantage earlier, whilst Slovenia had limited exposure to these policies prior to entering the EU (in 2004). Hence, it has not established a strong position on constructing regional competitive advantage and was more easily persuaded into the merits of niche specialization through entrepreneurial discovery as proposed through the S3 policy (Karo et al., 2017; Bučar & Rissola, 2018). In contrast, Scotland's context of regional devolution within the UK made it more sensitive to the regional competitive advantage opportunities for economic diversification and hence more reluctant to abandon it in favor of more open entrepreneurial discovery-based policy processes (Mastroeni *et al.*, 2017). This proposition would certainly require further empirical (and theoretical) exploration.

Perhaps somewhat worryingly, such different (societal) contexts are clearly shaping (at least part of) innovation policy (Bennett, 2008). Given the institutional obduracy of the organizational momentum behind these path-dependencies (Boschma & Frenken, 2011;

Valdaliso et al., 2014), they can also turn into a self-fulfilling prophecy-like vicious circle, as the perceived precedence of one or the other type of intervention can in the long run deplete the key complementary aspects of a sustainable innovation or entrepreneurial (eco)system (Radosevic & Myrzakhmet, 2009). On one hand, if R&D is dominant, commercialization can become neglected, leading to a slow (or even blocked) path to market and loss of competitive advantage. On the other hand, if BD investment is favored by policy, then the level and quality of R&D can be eroded – note the identified need for more project work and its translation across stakeholders in the Scottish case – also leading to a potential eventual loss of competitive advantage as other regions with more advanced R&D activity may emerge in fast-paced high-tech domains (Parikh, 2001).

Innovation and (Political) Agendas: Towards an Answer?

Hence, the ten million euro dilemma has returned in full force. While one can pinpoint the available options for any new innovation intermediary intervention to deliver on a smart specialization-type policy, the understanding of which (mix of) mechanisms should be delivered depends greatly on the analysis of the (sectoral, geographical, and socio-economic) context[38]. What the two case studies presented here show is that though such decisions should primarily focus on the identified need within the geographically-bound sectoral innovation system they are part of, they also relate to policy path-dependencies, and crucial differences can emerge, which can potentially, in the long run, lead to counter-productive depletion of regional competitiveness.

As such, this paper tentatively proposes that using a comprehensive innovation intermediation framework as outlined earlier (Vidmar, 2018) as part of the policy-making toolkit can improve the strategic thinking beyond the often dichotomous and entrenched "more-of-the-same" approach often adopted, with an aim of balancing R&D and BD support (Autio, Kanninen, & Gustafsson, 2008). Though there have been other examples of direct R&D investment in the New Space sector in Scotland (e.g., UKube-1 in particular, but also SMART Awards funding) and more BD-oriented projects in Slovenia (e.g., the spin-off success of TRIsat satellite co-developer SkyLabs), these are, so far, much smaller investments than

[38] This complements currently developed novel statistical methods for S3 policy-making, such as research by Kotnik and Petrin (2017) in Slovenia.

the lead projects described in this paper and only further illustrate the importance of combined BD and R&D support provision on an equal scale (Nishimura & Okamuro, 2011).

Having examined these two innovation intermediation examples at an early stage, it is hoped that with longitudinal tracking, further insights into the evolution of these projects will emerge over time. Of particular interest would be more extensive comparative analyses of other (groups and types of) intermediaries and their intervention mechanisms, both within a sector in different regions[39] and in different sectors within one region. Equally interesting would be a more detailed longitudinal/evolutionary analysis of the application of different policy frameworks for the establishment of innovation intermediation projects and its relationship with the proposed typology. Overall, such further studies, as well as the observations presented here, can assist in bridging the gap between the conceptual vision for smart specialization policy and its operational implementation through innovation intermediation interventions, with opportunities for updating both the theoretical framework and practical recommendations.

[39] Given that tourism is an S3 opportunity area in both Slovenia and Scotland, direct comparative studies such as the one by Daugėlienė and Brundza (2009) are of great value to detailing path-dependency trends and innovation policy processes further.

DISSCUSION

Chapter 7: A Multi-level Perspective Geographically-bound Sectoral Systems of Innovation Framework (MLP-GSSI) for Analysing Open Innovation Transition in SMEs

Introduction: The Open Innovation Challenge to STS and IS

The interest for the innovation and the role it plays in economy is ordinarily traced back to Schumpeter's seminal work on entrepreneurship and wealth creation (Malerba and Orsenigo, 1995; Malerba *et al.*, 2016). The research has since then split into organisational and behavioural studies on one hand - examining the micro-level processes of innovation and their relationship to change and growth - and on the other hand, the macro-level economic and social theory, examining the effect of innovation on the economy and society as a whole or its parts (Castellaci *et al.*, 2005). Furthermore, a second split emerged along the differences of the epistemological commitment of scholars, with the field of "innovation studies" (IS) adopting a more normative positivist approach within the domain of critical realism, whilst "science and technology studies" (STS) took a turn towards a more localist and constructivist interpretivism (Williams, 2019). This resulted in a myriad of approaches and theories within broader innovation research, whose lack of inter-relation and integration is a key issue for forming and deploying successful economic development policy (Asheim, Grillitsch and Trippl, 2017). However, Williams outlines a potential opportunity for

> *"STS and IS scholars to recombine around a role as conscious co-shaper of science and innovation policy and practice" (Williams, 2019, p. 12).*

He argues this to be particularly relevant now, due to innovation studies recent interest in deeper understanding of socio-technical transitions around economic and social sustainability. However, a persistent challenge remains as to how these approaches can be recombined in practice (Velasco, 2015; Williams and Velasco, 2016), partially due to the divergent interests as well as (current) political success of the dominant innovation studies paradigms.

The resulting divergence is clear to see on both the macro- and micro level and in terms of their focus and impact. On the macro-level, IS' quite normative conceptualisations of innovation systems (Nelson and Nelson, 2002; Edquist, 2004; Lundvall, 2007) are often dominating economic policy arena, while STS analytical accounts of multi-level technological transitions (Kemp, Schot and Hoogma, 1998; Rip and Kemp, 1998; Geels, 2002) are more dominant in academia and within regulatory/governance frameworks development. On micro level, IS focused on the mechanics of the processes of innovation (Cohen and Levinthal, 1990; King, 1992; Pavitt, 2003), whereas STS looked more at inter-organisational learning and laboratory studies (Latour, 1983; Sørensen, 1996; Knorr-Cetina, 1999; Hyysalo and Stewart, 2008). In turn, main points of (recent) theoretical convergence are related on the macro-level to the "messy/non-linear" ontology of innovation (Godin, 2006; Pollock and Williams, 2008; Koutsouris, 2012), and the increasing role of "users" in the micro-level processes (Urban and von Hippel, 1988; Fleck, 1993; Malerba, 2007; Hyysalo, 2009).

One area where further convergence might be established is in the bridging of the micro-macro split in both IS and STS approaches, harnessing the current transition in the conceptual definition of "innovation", from a broadly "closed" to an "open" model, which is present in both fields. Specifically, the macro-micro split has been widely criticised both in the STS (Vanderburg, 1987; Wyatt and Balmer, 2007; Williams and Pollock, 2009) as well as in IS (van De Ven and Rorgers, 1988; Lundvall *et al.*, 2009) literatures. Consequently, the integration of the two main levels of study through a meso-level understanding of various interactions between groupings of actors was called for as a potential solution. For instance, Green et al. (Green *et al.*, 1999) advocated for:

> *"[…] analyses [which] would be focused on the meso-level networks of institutions and actors at work in, for instance, geographically bounded systems of innovation, scientific and technological disciplines, firms and their strategies and informal linkages, and in specific examples of the nexus between production and consumption"* (Green *et al.*, 1999, p. 790)

Attempts to adopt such approaches to the study of innovation are mainly grounded in "co-evolutionary" theories, present in both IS as well as STS approaches (Coombs *et al.*, 2001; Geels, 2004; Malerba, 2005) and point out the interdependence of the various levels. For instance, Dosi and Winter are explicitly noting that:

> *"[T]he relation of the "higher level" regularities manifested in institutions, rules and organizational forms to "lower level" evolutionary processes is a complex one of co-evolution across levels of analysis and time scales -- and ought properly to be modeled as such."* (Dosi and Winter, 2000, p. 6)

In practice, however, the relationships between the top-level institutional regularities and the bottom-up innovation processes are often exposed through the empirical study of innovation through examining "change" and "transformations/transitions" (Abernathy and Utterback, 1978; Acs and Audretsch, 1988; Geels, 2002, 2005; Tidd, Bessant and Pavitt, 2005; Axtell, Holman and Wall, 2006), though they are not systematically modelled. In particular, the recent transition towards "Open Innovation" (OI) model of new product development (NPD) is of significant interest, as both analysts, as well as practitioners, find it challenging to connect dispersed insight.

OI marks a paradigm shift in understanding the supra-organisational nature of innovation in some of the most fast-growing economic sectors in the late 20th and early 21st century (Chesbrough, 2006). Its main premise is that on one hand, if the processes of innovation are contained within the organisational entity steering them, in most cases a firm, this constitutes a "closed" innovation model. On the other hand, if these processes cross the firm's boundary, they are considered as part of an "open" innovation model. This includes both "outsourcing" the commercialisation of innovative ideas as well as ideas/knowledge being "insourced" into the firm's NPD process from outside. When Chesbrough (2006) introduced the notion of OI he explained it as placing "external ideas and external paths to market on the same level of importance as that reserved for internal ideas and paths" (2006, p. 43). More recently, this was re-phrased into:

> "open innovation as a distributed innovation process based on purposively managed knowledge flows across organizational boundaries, using pecuniary and non-pecuniary mechanisms in line with the business model" *(Chesbrough and Bogers, 2014, p. 12)*

Hence, there is a growing need to create new frameworks which "connect these seemingly disparate activities together" (Chesbrough, 2011) to make it easier for innovation practitioners to link-up to other sources of knowledge and expertise. As most of these processes are based on interaction with external-to-firm/organisation partners through communication and sharing between individuals and organisations (Brown and Duguid, 2001), a key part of any open innovation model is its interconnectedness (Simard and West, 2006). By investigating the relationship between the actors involved in the development of new products, one can hope to achieve a new understanding of the open innovation social structures and organisational behaviour, both in terms of the micro-level innovation management (Lichtenthaler and Lichtenthaler, 2009; van de Vrande *et al.*, 2009; Spithoven, Clarysse and Knockaert, 2010), as well as in how it is itself co-shaped by the wider context of the macro-level system (Antikaninen, Mäkipää and Ahonen, 2009; Kerry and Danson, 2016; Reid and Maroulis, 2017).

How such an understanding can be is built is less clear. In particular, increasing attention is being paid in OI literature to understanding the small-end of the spectrum of companies, i.e. the small-to-medium-sized enterprises (SME). SMEs are both increasingly recognized as crucial for the overall economic performance of locales, regions, countries, global areas (Vonortas, 2002), as well as most dependent on the interconnectedness to other actors to remain competitive through innovation (Spithoven, Vanhaverbeke and Roijakkers, 2013; Iturrioz, Aragón and Narvaiza, 2015). A very comprehensive review of state of the art in OI literature in relation to SMEs has been compiled by Hossain and Kauranen (2016), where they identified as particular interest going forward the change of SMEs' innovation "from closeness to openness" and "management of openness". Though some of the mechanisms of open innovation in SMEs were charted by Lee et al. (Lee *et al.*, 2010), these additional areas of research are related to understanding the "diffusion of open innovation", for instance

> *"[…] whether firms adopt more open approaches based on an active strategic intention or rather as a reaction to competitive pressures. Furthermore, the need to understand the relation between the strategic approach to open innovation and a firm's capabilities and culture of managing technology has to be emphasized."* (Lichtenthaler, 2008, p. 155)

This again exposes the critical distinction between the micro ("technology management") and macro ("strategic approach") level understanding, the interdependence of the two and the growing need for developing a multi-level perspective on the OI model, also explicitly called for by lead authors of the paradigm's analysis (West, Vanhaverbeke and Chesbrough, 2006; West *et al.*, 2014).

In the first part of this paper, I am proposing to address this issue within OI model by deploying two leading frameworks within both STS and IS fields, the multi-level perspective (MLP) and geographically-bound sectoral systems of innovation (GSSI) respectively. Examining their strengths and weaknesses in the next two sections, I then propose a new way of combining the two can lead to a more robust approach to examining the OI transition. This is building on a previous attempt at theoretical alignment (Geels, 2004), but addresses a critical conceptual mismatch between the two theories. In addition, in the second part of this paper, the newly developed framework is then contextualised on the specific example of the transition to OI within the New Space sector in Scotland. Through this, analytical theories applicable to each of the newly developed elements/levels are proposed, as well as linkages between them, overall arguing for a more holistic and unified theory of innovation.

PART 1: Towards a Multi-level Systemic Perspective

Science and Technology Studies Approach - Multi-Level Perspective (MLP)

The challenge of joining-up the micro and macro approaches within the broad STS theorisation of innovation has been taken up by proponents multi-level perspectives (MLP). These have been formed since the late 1990s (Rip and Kemp, 1998; Geels, 2002; Genus and Coles, 2008) and are defined by examination of innovation across three levels: micro-level "niches", meso-level "regimes" and macro-level "landscapes", as part of "a nested hierarchy" (Geels, 2005). These respectively correspond to transitions as seen by the development of (radical) innovations, the changes to the sets of rules actors (informally) abide by in their interaction and the overarching structural trends (Geels, 2002). It is important to note, that whilst the different levels traditionally correspond to a different framing of changes/transitions, they are not independent of each other and the "higher" levels include and reflect the phenomenology of the lower ones, which "break-through" into established regimes (Geels, 2004).

Though MLP has been extensively deployed using a historiographical methodology, contemporary research in a variety of technological and socio-economic and political contexts was also carried out as reviewed by Genus and Coles (2008), pointing out key issues with MLP deployment, noting that

> *"[…] research could seek to extend existing knowledge by attempting to apply the MLP more systematically than has sometimes been the case […]. This could help to interrogate the operationalisation of the MLP and the plausibility of explanations made in its name about the nature of the transitions."* (Genus and Coles, 2008, p. 1444)

Some authors go further still in proposing that challenges of deploying MLP systematically are rooted in unclear ontology and epistemology positions, in particular, seen through studies contrasting MPL framework with the premises of critical realism (Sorrell, 2018; Svensson and Nikoleris, 2018). Amongst other challenges, there are two specific concerns about "reducing transitions to shifts in the maturity and dispersion of socio-cognitive rules" (Svensson and Nikoleris, 2018) and "the tendency to use theory as a heuristic device rather than causal explanation" (Sorrell, 2018).

I propose that these two concerns could be addressed by developing better tools to understand the linking between the three levels of MLP analysis. In particular, I argue, this can be achieved by defining frameworks and theories for (causal) interrogation of the linkages between socio-technical regimes (ST-regimes) and socio-technical systems (ST-systems).

Geels (2004) proposes ST-regimes as "meta-coordination" of the "interdependence" of different actor groups through "alignment of rules" which govern them. In the same framing, ST-regimes are explicitly said to be the "'deep-structure' or grammar of ST-systems". ST-systems are themselves defined as "the linkages between elements necessary to fulfil societal functions (e.g. transport, communication, nutrition)" (Geels, 2004). These definitions are in of themselves rather unclear, which is hampering the development of systematic causal theories. For instance, in order to develop and deploy any systemic solution, the studied socio-technical system needs to be better defined, since, as noted by Smith, Voß and Grin (2010):

> *"[M]aking the core concepts of niche, regime and landscape operational for empirical research is a question of bounding, partitioning and ordering the system under study."* (Smith, Voß and Grin, 2010, p. 444)

I argue that addressing the challenge of defining and bounding the socio-technical system would be a fruitful point of departure to integrate the STS' MLP approach with IS' strengths of producing and meaningfully deploying boundaries within the analysis of innovation systems, as well as develop a coherent set of analytical elements which can be studied using theoretical tools. Hence, in the next section, I review the strengths and weaknesses of the IS' innovation systems approach, before moving on to proposing its integration with MLP.

Innovation Studies Approach - Geographically-bound Sectoral System of Innovation (GSSI)

Over the past few decades, the Innovation Systems literature has provided a conceptual framework for a better understanding of the occurrence and net effect of innovation on different units of economic analysis. However, differentiation within the literature led to the establishment of several strands of "innovation systems" based on different foci of enquiry tailored for the scope and aims of different researchers' interest. For instance,

> *"Edquist (2005) has argued that system boundaries may be defined in one of three ways: spatially/geographically; sectorally; and in terms of system activities or functions."* (Asheim, Smith and Oughton, 2011, p. 884)

In particular, various authors have framed the innovation systems model using geographical boundaries such as national (Freeman, 1991; Lundvall *et al.*, 1992, 2002; Nelson, 1993) or regional (Cooke, Gomez Uranga and Etxebarria, 1997; Cooke, 2001; Asheim, Smith and Oughton, 2011) units. Conversely, some authors focused on the separation of economic activities into (different) technological (Hekkert *et al.*, 2007) or sectoral (Malerba, 2002, 2004a, 2005) groupings. Finally, depending on the perspective taken, studies have focused on the role of policy (Smits and Kuhlmann, 2004; Isaksen, 2012), intermediary organisations (Hannon, Skea and Rhodes, 2014; Kivimaa, 2014; Mgumia, Mattee and Kundi, 2015), research (Kerry and Danson, 2016), and other activities and functions.

However, many authors noticed that in the empirical framing of the innovation systems, multiple of these types of boundaries are deployed simultaneously (Porter, 2000; Edquist, 2001; Cooke, 2002a; Tallman *et al.*, 2004; Boschma and Frenken, 2012; Faber and Hoppe, 2013). In the Sectoral Systems of Innovation (SSI) framework, which focuses most intensely on understanding knowledge as one of the core element of the innovation system, defining the boundaries is referred to by the main authors as an integral property of the system itself, noting that

"[B]y focusing on the sources of knowledge and on the role played by geographical space in the processes of knowledge transmission, the boundaries of SIS are endogenous: they emerge from the specific conditions of each sector." (Breschi and Malerba, 1997, p. 131)

Such an approach to innovation systems' analysis implies an interplay of two (related) sets of boundaries – sectoral and geographical. To begin with, by understanding the studied processes within the SSI, relevant actors are identified as all belonging to the "sector" by the virtue of being part of the same value chain of a specific innovative endeavour (Hansen and Birkinshaw, 2006; Roper, Du and Love, 2008). Specifically, Malerba's definition is that a sector is based on:

"a set of activities which are unified by some related product groups for a given or emerging demand and which share some basic knowledge" (Malerba, 2005, p. 65)

In addition, geographical boundaries are formed from the empirical work, though Malerba specifically notes

"often in a sectoral system, one may find the coexistence of local, national and global boundaries: global for knowledge interaction; local for the labour market and national for some key institutions." (Malerba, 2005, p. 68)

However, I argue that equal emphasis should be put on both sectoral and geographical boundaries and that the geographical dimension should be acknowledged more fully within the SSI analysis. This is not to argue against the above point about the multiplicity of boundaries but on the importance of understanding how multiple dynamics play out in a geographically and sectorally bounded context[40]. As noted by Edquist,

"[…] it should be a matter of choosing geographical areas for which the degree of 'coherence' or 'inward orientation' is large with regard to

[40] For instance, examples of the parity and assumption are statements such as "it is important to note that innovation systems differ between <u>countries and sectors</u>" (Faber and Hoppe, 2013) and "successful biotechnology clusters with a full range of systemic interaction mechanisms exist and, while unique in many ways, offer lessons for systemic regional innovation in other <u>sectors and regions</u>" (Cooke, 2002a).

innovation processes." And that while "[…] specific technologies or product areas define the boundaries of sectoral systems, but they must also normally be geographically delimited." (Edquist, 2001, p. 14)

Here it is important to stress that whilst the primary interest in most of SSI studies is on sectoral/technological dynamics - due to the key focus on knowledge as sectoral enabler and integrator and the assumption that in the current socio-economic environment no actors are entirely dependent on any rigid geographical boundaries – this is played out in specifically localised and increasingly local domains (Ndou *et al.*, 2012; Weidenfeld, 2013). Hence, I argue we should ensure the analytical frameworks referred to as geographically-bound sectoral systems of innovation (GSSI), explicitly defining the importance of both sectoral as well as geographical boundaries as part of the study.

So far, the research in SSI has mainly focused on sectors of industrial production, even though the framework has also been adopted in studying more knowledge intense sectors (Breschi and Malerba, 2005), in particular, bio-tech (Cooke, 2002b, 2002a), pharmaceuticals (McKelvey and Orsenigo, 2001) and IT (Christensen, Olesen and Kjær, 2005; Ferrary and Granovetter, 2009). However, the resulting studies are often very descriptive in nature and the overall Innovation Systems literature's lack of solid theoretical framework was often problematized (Lundvall *et al.*, 2002; Geels, 2004; Bergek *et al.*, 2008). For instance, Lundvall et al. specifically mention that

"[T]he incomplete character of the synthesis affects the possibility of studying large-scale phenomena like the creation, transformation and passing away of innovation systems as well as the possibility of a systematic link up to larger bodies of knowledge like, e.g. evolutionary theory and more standard theories of growth and development."
(Lundvall *et al.*, 2002, p. 222)

In addition, due to "conceptual heterogeneity in the innovation system literature", practitioners and analysts often struggle with applying consistent and comparable methods and tools (Bergek *et al.*, 2008). Hence, I propose a further systematic link to other theoretical approaches in the (co-)evolutionary tradition as a way forward, as well as fleshing out analytical frameworks for studying the (G)SSI's elements on a case by case basis. Looking for synergies with the parallel STS tradition, merging aspects of (G)SSI with MLP, itself struggling with some aspects of theoretical vulnerabilities, might just be able to improve both approaches.

Towards MLP-GSSI Integration

A particular opportunity to address the challenge of lack of theoretical strength in innovation systems studies and at the same time integrate the MLP approach with (sectoral) innovation systems theories has been identified by several authors (Geels, 2004; Markard and Truffer, 2008; Weber and Rohracher, 2012). Of particular note is both of the theories core interest in regimes, traced back to the same roots in *The Evolutionary Theory of Economic Change* (Nelson and Winter, 1982) – though taken in divergent directions, as they were developed into "sociotechnical regimes" of "semi-coherent set of rules carried by different social groups" in MLP (Geels, 2002) and "technological regimes" defined "in terms of levels of opportunity, appropriability, and cumulativeness of innovation, and in terms of its specific knowledge base" in SSI (Malerba and Orsenigo, 1990, 1997; Breschi and Malerba, 1997). The difference between the two framings mirrors the critical split between the more historiography-based STS-inspired (MLP) interpretivism and traditional IS' (SSI) more normative approach. However, MPL scholars suggested a particular opportunity for the two theories' integration being the recognition of the analytical split between

> *"systems (resources, material aspects), actors involved in maintaining and changing the system, and the rules and institutions which guide actor's perceptions and activities"* (Geels, 2004, p. 898).

Such conceptual split somewhat resonates in Malerba's conceptual definition of SSI as having

> *"three building blocks: knowledge and technologies, actors and networks, and institutions"* (Malerba, 2005, p. 63)

Specifically, Geels proposes a "widening from sectoral systems of innovation to socio-technical systems", "which encompass production, diffusion and use of technology" and "consist of artefacts, knowledge, capital, labour, cultural meaning, etc." (Geels, 2004). Here, past issues for integration of the two theories emerged, which, I argue, is partly a result of MLP proponents not being entirely clear on what constitutes the socio-technical system from the perspective of their own theoretical standpoint. This led to SSI being equated with MLP's conceptualisation of socio-technical systems, whilst SSI de facto incorporated all three of the analytical elements proposed by MLP.

To resolve this mismatch and integrate the two theories, and thus both addressing their weaknesses as well as play into their strengths, I propose to reframe the way the building-block concepts from each are compared and integrated. In particular, I argue that the MLP definition of the socio-technical system should be equalised with that of knowledge and technologies within SSI ("specific knowledge base, technologies and inputs" (Malerba, 2005)) – making a combined definition of socio-technical system of knowledge/technologies (STSKT). In addition, I argue that the overall/broader (SSI) "system" should be called a socio-technical assemblage (STA)[41]. The STA is, hence, based on the socio-technical system of knowledge and technologies, actors/networks and socio-technical regimes (which as outlined earlier are the combined total of institutions/rules). Based on the initial conceptualisation of the MLP's meso-level as socio-technical regime (Geels, 2004) derived from a "patchwork of regimes" (Geels, 2002), I propose that this wider socio-technical assemblage definition is a helpful theoretical expansion of the meso-level of MLP.

MLP scholars suggested the above split (of STA) to systems (now STSKT), actors and institutions is "useful to make analytical distinctions, because it allows exploration of interactions between categories" (Geels, 2004). This is complementary to some of the directions for further research proposed within the SSI approach, noting that there should be a

> *"focus on systemic features in relation to knowledge and boundaries, heterogeneity of actors and networks, institutions and transformation through coevolutionary processes."* (Malerba, 2005, p. 63)

Reading the two frameworks combined, hence, I advocate for (empirical) investigation of how the socio-technical systems of regimes' elements are interrelated (MLP) and how they individually operate (SSI). However, on the issue of how to do so, the two approaches offer only a limited epistemological guidance and are consequently exposed to the criticism of a lack of systematic analysis and theoretical clarity in the application of the two frameworks. I propose this can be resolved by a two-step approach – the merger of the foci of the two

[41] The term "socio-technical assemblage" has been proposed in similar (though not directly related) contexts before (Bellanova and Duez, 2012; Bulkeley, Castán Broto and Edwards, 2015), and has been defined as "heterogeneous systems composed of elements that are both material and immaterial, both physical and textual" (Bellanova and Duez, 2012). There is a good overview of the "assemblage" and its application to actor-network relationships in Müller (2015).

frameworks, i.e. to analyse both the STA/SSI elements and the linkages between them, and to propose for empirical studies to pro-actively develop definitions of the applicable analytical theories, as will be attempted later in this paper on the basis of my interest in open innovation transition.

In order to achieve such a comprehensive merger as I propose, I make two critical observations.

Firstly, the SSI elements also exhibit an implied multi-level "nested hierarchy" – symmetrical to the MLP approach. Upon deeper examination, MLP proposes that socio-technical systems (now STSKT) "do not function autonomously, but are the outcome of the activities of human actors" who in turn are "guided" by rules/institutions, which take the form of socio-technical regimes (Geels, 2004). In similar relational terms, SSI proposes that "innovation is considered a process which involves systematic interactions among a wide variety of actors for the generation and exchange of knowledge", which are "shaped" by the institutions (Malerba, 2005). Though notionally these represent a flat ontology (Geels, in particular, insists on such approach by defining "six interrelated analytic dimensions" (Geels, 2004)), both through theoretical development as well as empirical work it has been established that due to the central epistemological role of actors, the institutional/ST-regime and STSKT elements are positioned and understood in relation to that of actors (Alvarez and Barney, 2010; Geels, 2010; Vasilachis de Gialdino, 2011). This is consistent with the critical realist perspective, which, whilst rejecting subjectification of non-actor entities, ranks their interpretative position beyond those of other structures, hence creating a compromise position between (STS) interpretivism and (IS) positivism (Sorrell, 2018). Hence, I argue that there is an implied nested hierarchy within the combined STA/SSI approach, with elements ranked from macro-level institutions/(ST-)regimes through meso-level actors/networks and towards micro-level STSKT.

Secondly, there are many applicable theories to examine each of the element-levels and links between them. Hence, in constructing the proposed analytical framework, any study needs to focus on proposing a set of analytical theories fitting its objectives. In particular, these are related to a specific studied change/transition and the geographical and sectoral boundaries deployed. To make inter-level linkages possible the focus is often applied to a single transitional mechanism, and usually starting its investigation at the level of actors/networks, and spreading from there through to institutional/regime and STSKT levels.

In the second part of this paper, I build a case for applying this framework to my particular analytical study - the open innovation transition, and specifically the interconnectedness of actors involved. The expansion of the MLP's meso-level with the (geographically-bound) SSI as socio-technical assemblages, provides for a critical starting point to fleshing out the analytical (empirical) examination of each of the elements-levels and then engage with applicable specific theories. Furthermore, on the interest of open innovation and through its (hierarchically) interlinked building blocks of institutions/ST-regimes, actors/networks and STSKT, it creates a polygon to translate the socio-economic and policy trends, through understanding the links amongst the various actors and into new product development. However, for this structure to be mobilised, analytical frameworks for understanding both the three levels-elements themselves and the two links between them have to be developed with relation to the leading questions in understanding the open innovation transition. This is explored in the case of the New Space Sector in Scotland.

PART 2: MLP-GSSI Analysis of Interconnectedness in Open Innovation Transition Case Study

Of particular concern for exploring these specific issues with the use of MLP-GSSI approach on OI transition are the concepts of "Innovation policy/competitive advantage/smart specialisation", "networking and social learning" and "absorptive capacity/organisational learning", as is wildly discussed in the literature (Chesbrough, 2006; Spithoven, Clarysse and Knockaert, 2010; Iturrioz, Aragón and Narvaiza, 2015; Reid and Maroulis, 2017). Hence, the rest of this paper is outlining the MLP-GSSI approach to studying the open innovation transition's mechanisms within SMEs through: a) a clear linking between the three elements of STA/SSI-driven analysis and b) a contextually proposed definition of "useful framing" of the three element's' "open innovation" changes/features. As such, using MLP-GSSI approach, I developed a series of analytical frameworks to examine the mechanisms of OI transition within STSKT, actors/networks and the ST-regimes/institutions as outlined in Figure 20.

Reflecting the proposed symmetrical multi-level structure within STA/SSI and applying open innovation example to each level and transition (presented in the next sections): firstly, pragmatically examining the innovation systems conceptualisation and its relationship to innovation policy, I propose institutional-macro-level perspective is best captured within the studies of geo-sectoral innovation policy. Secondly, I propose that understanding the innovation intermediaries interventions and their roles within the GSSI is linking the institutional element-level with the actors/networks one. Thirdly, there is an interesting body of literature in the construction and deployment of Living Laboratories (Living labs) as a stable configuration of actors/stakeholders in open innovation paradigm, which could form the core of the meso-level actor/network STA/SSI element. Fourthly, through analysing the convergence of a variety of organisational learning, knowledge management and new product development models the translational concept of "innovation moments" within new product development (NPD) is proposed to, link the meso-level Living Lab with the micro-level structural absorptive capacity. Fifthly, the wealth of OI interest in the micro-level (STSKT) element of absorptive capacity is explored proposing structural interpretation.

The (New) Space Sector in Scotland

This approach is explicitly contextualised through my work on understanding OI transition within the SME-driven (New) Space Sector in Scotland (Vidmar, 2015, 2019b, 2019c; Vidmar *et al.*, 2020). As per GSSI principles, I am deploying both a geographical and sectoral boundary, since my research is both regionally localised (Scotland) and covers a specific sectoral economic activity (the Space Sector). On the theoretical focus side, it has a substantive interest in the effect of innovation intermediation on new product development and the origins of its mandates in innovation policy.

In particular, the global Space Sector is currently undergoing an industry transition to "New Space", including opening up the innovation processes and increasing importance of SMEs and systemic approaches to NPD. Though "open innovation" was initially proposed from the perspective of big corporations, SMEs are facing a very challenging environment in the fast-paced knowledge economy, too. In particular, increasing knowledge complexity and its wide(er) distribution makes it far more difficult for an SME to innovate by itself. The mechanisms of Open Innovation in SMEs were charted by Lee et al. (2010) and involve potential insourcing of knowledge and resources (investment) and outsourcing of IP and establishing new business models or entering new markets. These concerns are further highlighted through the increasing political interest in high-tech innovation as a driver for economic development and relating multitude of the Space Sector's applications to key grand societal challenges, in particular, those of sustainability.

My overall argument is that the living laboratories' are "network/actor" groupings, led by innovation intermediaries and prime SMEs, who are co-creating the "ST-regime/institutions" to further the “landscape” shift to open innovation. These regimes are in turn co-created in relation to NPD processes’ structural absorptive capacity (STSKT), as mediated through innovation moments.

As mapped out on Figure 20, I link the exertion of a landscape change towards OI through geo-sectoral innovation policy of developing a “Space Glen” in Scotland, to the role of institutions in the examined STA (Vidmar, 2020). Implementing such policy amongst actors and networks is managed through interventions by innovation intermediaries, for which a typological understanding and empirical mapping can further both analytical clarity as well as operational applicability (Vidmar, 2018, 2019c). This can be demonstrated specifically, using detailed comparative case studies (Vidmar, 2019e). The actor/network interfaces are proposed to be examined through the emergence of the Living Lab concept, and its application to the Scottish vision for an Agile Space brand – a loose consortium of SMEs covering the entire value chain (Vidmar, 2019b). Finally, through using innovation moments to probe the networked organisational learning and thus, I propose to illuminate some of the aspects of structural absorptive capacity (Vidmar *et al.*, 2020).

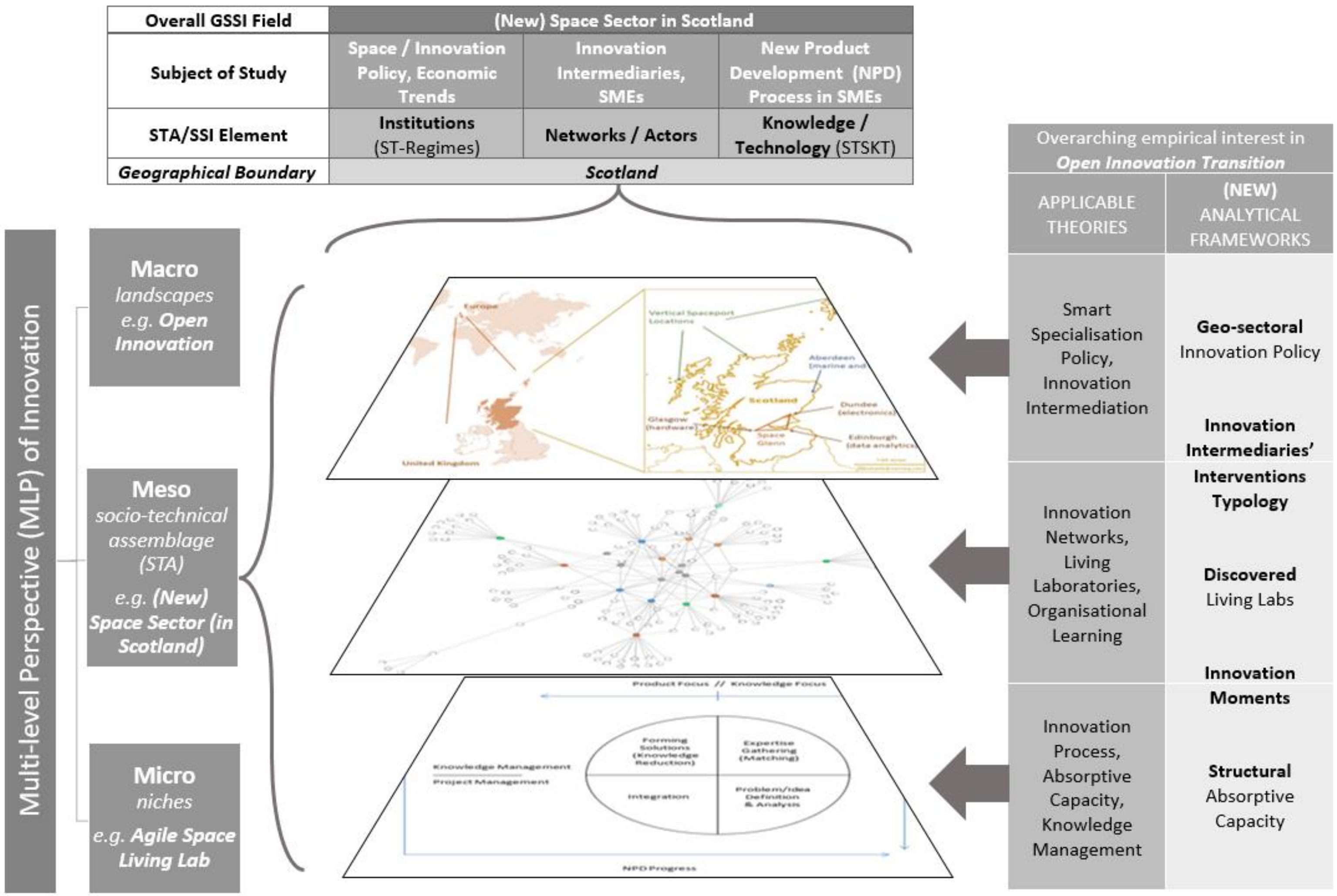


Figure 20 - Outline of MLP-GSSI integration and the development of the analytical frameworks applicable to the OI transition in the (New) Space Sector in Scotland case study

Level-elements' Analytical Frameworks

Macro Level-Element: Geo-sectoral Innovation Policy

A major stepping stone to frame the transition to open innovation is to understand its drivers, in particular with reference to the socio-economic and policy dimension as framed by public policy. The role of (innovation) policy in the OI transition is well documented in the literature (Chesbrough and Vanhaverbeke, 2011; Wynarczyk, Piperopoulos and McAdam, 2013; West *et al.*, 2014). In addition, Open innovation concepts have been directly related to the development of regional systems of innovation – in particular through policy initiatives (Kerry and Danson, 2016). Furthermore, as directly related to GSSI framing, there is an emergence of geo-sectoral (innovation) policy in economic development literature, though the term itself is only seldom used[42]. This is particularly poignant in the context of sectoral specialisation within the regional economic development policy through the framing of competitive advantage (Porter, 2000; Zahra and George, 2002; Tallman *et al.*, 2004), in particular in the context of European policy of Smart Specialisation (Foray and Goenaga, 2013; Mccann and Ortega-argilés, 2017). Using the MPL-GSSI approach to contain and probe these policies can lead to both analytical as well as normative findings, specifically when focusing in on analysis of socio-economic trends and geo-sectoral structure(s).

Macro-Meso Level-Element Linkage: Innovation Intermediaries' Interventions Typology

The critical link between the macro and meso-level framing of the open innovation transition is the way policy is operationalised from an abstract conceptual model into an inter-organisational network by various (organisational) actors. This is often done by organisations who are a (in)direct product of innovation policy, without an individual stake in the innovation process. One such dominant group, in particular, are the innovation intermediaries. Innovation intermediaries literature has been developed around the central notion of innovation being supported by a type of organisations interacting between the various actors engaging in the innovation processes (Howells, 2006; Winch and Courtney, 2007; Dalziel, 2010; Abbate, Coppolino and Schiavone, 2013; Kivimaa, 2014; Kim, 2015; Mgumia, Mattee and Kundi, 2015). Critically, these are increasingly studied and deployed

[42] I could find almost no references to the term "geo-sectoral" in any context, but economic development and foreign direct investment literature has a few instances of use (Lemaire, 2010; Chapman and Meliciani, 2018).

within open innovation context (Chesbrough, 2006; Antikaninen, Mäkipää and Ahonen, 2009; Lee *et al.*, 2010; Agogué, Ystrom and Le Masson, 2013; Katzy *et al.*, 2013; Kokshagina and Masson, 2015). However, the understanding of innovation intermediaries is fragmented, incomplete and lacks operational clarity (Van der Meulen *et al.*, 2005; Howells, 2006; Dalziel, 2010; Abbate, Coppolino and Schiavone, 2013; Hannon, Skea and Rhodes, 2014). Hence, in order to understand the operationalisation of emerging open innovation institutions/ST-regimes as related to the deployment of (geo-sectoral) innovation policy further understanding of innovation intermediaries and their interventions should be sought, in particular by establishing a functional typology applicable not only in analytical, but also operational contexts. Furthermore, I proposed that better understanding the details of these processes and the structure and effect of innovation intermediaries, their interventions and their underlying political mandates, can enable a fresh, integrated perspective on the role of OI in emerging sectors, both to refute some of the simplistic views of the OI transition, as well as expose some challenges of geo-sectoral innovation policymaking.

Meso Level-Element: Discovered Living Lab(s)

The understanding of open innovation actors and the structural features of networks they create is perhaps the most well developed of the three STA/SSI elements, likely in part due to epistemological primacy of actors, as well as due to the (related) interest in shaping their behaviour, in much more direct way than in the case of institutions/ST-regimes and STSKTs. A change in pace in the understanding of the (actor-)networked perspective of open innovation (Vanhaverbeke and Cloodt, 2006; Lee *et al.*, 2010; Pullen *et al.*, 2012; Iturrioz, Aragón and Narvaiza, 2015) is linked with the conceptualisation of Living Laboratories or Living labs (Feurstein *et al.*, 2008; Følstad, 2008; Almirall, Lee and Wareham, 2012), which was specifically contextualised as an instance of open innovation (Almirall and Wareham, 2008; Bergvall-Kåreborn *et al.*, 2009; Kareborn and Stahlbrost, 2009; Leminen, Westerlund and Nyström, 2012; Schuurman, De Marez and Ballon, 2016). The particular theoretical interest within the Living Labs conceptualisation is the analytical shift from the pervasive, yet outdated linear “technology push” models (Godin, 2006; Di Stefano, Gambardella and Verona, 2012) to a more “fuzzy” or “messy” nature of new product development (Chidamber and Kon, 1994) with an increasing role of the users (Eriksson *et al.*, 2006; Levén and Holmström, 2008; Bergvall-Kåreborn *et al.*, 2009; Dell’Era and Landoni, 2014; Voytenko *et al.*, 2016). The resulting Living lab approach to innovation proposes problem-solving real-life innovation processes, managed through an interrelated group of stakeholders, from research organisations to entrepreneurs/businesses and final customers and users.

However, the particular applicability of Living Labs to the MLP-GSSI approach to open innovation transition is in their (semi-)stable configuration of actors' networks, enabling integrative experimentation between the ST-regimes and the STSKTs, by allowing actors to experiment with the configuration of these elements within innovation projects. However, interpreting the Living labs theories is difficult due to their applied nature and the focus on the construction of the Living Lab, rather than its analytical exploration. Hence, I propose as a starting point, identification of the enabling contexts underpinning the Living lab experimentation, as outlined in Table 14. By cross-matching the key leading conceptual definitions, methodologies and component modalities of Living Labs, I specifically propose that (as another MLP-like symmetry) three bounding levels are deployed: ST-regime, actors/networks and STSKT. These three identifiers are further split into more "physical" and "social" elements, i.e. those which are more obdurate and those which are easier to change. This produces a set of six enabling contexts for discovering Living Labs, which can be used as a guide to explore the configuration of actors within them and processes of experimentation they host (Vidmar, 2019b).

<table>
<tr><th>European Network of Living Labs Conceptualisation (Edwards-Schachter, Matti and Alcántara, 2012; ENLL - European Network of Living Labs, 2019)</th><th>Living Lab User Involvement Methodologies (Almirall, Lee and Wareham, 2012)</th><th>Key Components of a Living lab (Kareborn and Stahlbrost, 2009)</th><th>Proposed Enabling Contexts for a Living Lab</th><th colspan="2">MLP-like analysis</th></tr>
<tr><td rowspan="2">Multi-stakeholder Participation</td><td rowspan="2">User Centred</td><td rowspan="2">Partners</td><td>Geographically, Politically and Economically Bounded</td><td>Social</td><td rowspan="2">Actors/network</td></tr>
<tr><td>Appropriate Scale and Size</td><td rowspan="2">Physical</td></tr>
<tr><td rowspan="2">Real-life Setting</td><td rowspan="3">Design Driven</td><td>Application Environment</td><td>Diverse Natural Environment</td><td rowspan="2">STSKT</td></tr>
<tr><td>Technology and Infrastructure</td><td>Physical and Digital Infrastructure</td><td rowspan="2">Social</td></tr>
<tr><td>Multi-method Approach</td><td>Organisation and Methods</td><td>Research Capabilities</td><td rowspan="3">ST-regime</td></tr>
<tr><td>Co-creation</td><td>Participatory</td><td rowspan="2">User</td><td rowspan="2">Highly Skilled and Educated Workforce and Community</td><td rowspan="2">Physical</td></tr>
<tr><td>Active User Involvement</td><td>User Driven</td></tr>
</table>

Table 14 - The proposed set of Living Labs framework contextual identifiers.

Meso-Micro Level-Element Linkage: The Innovation Moments

Analytical and normative exploration of the transition between the abstract inter-organisational Living Lab framework and the innovation processes within organisations required a theoretical merger of the existing concepts on the two levels, situated within a specific temporal and spatial moment. Hence, I developed a novel transitional sensitising concept (van den Hoonaard, 2008) from the initial definition of "innovation moments" (Edwards, 2000; Edwards, Delbridge and Munday, 2005), which were analytically framed as procedural phases of NPD processes, or points of contention and departure for the progression of an NPD project. This advanced conceptualisation of an "innovation moment" was derived from a combination of knowledge management (Nonaka, Reinmoeller and Senoo, 1998), innovation process (Edwards, Delbridge and Munday, 2005), organisational learning (Crossan, Lane and White, 1999) and absorptive capacity (Zahra and George, 2002; Sun and Anderson, 2010) insights.

The emerging conceptualisation of four elements of “problem/idea definition”, “gathering expertise”, “forming solutions” and “integration”, was originally inspired by Nonaka et al. (Nonaka, Reinmoeller and Senoo, 1998) knowledge management typology, comprising of socialisation, externalisation, combination and internalisation of knowledge. Moreover, it builds on Sun and Anderson’s (Sun and Anderson, 2010) proposed integration of organisational learning theories with the concept of “absorptive capacity” by aligning the processes of intuiting, interpreting, integrating and institutionalising knowledge (Crossan, Lane and White, 1999) with acquisition, assimilation, transformation, and exploitation of knowledge (Zahra and George, 2002), respectively. Furthermore, this conceptualisation of the innovation process is very much aligned with empirical evidence established in prior studies of innovation processes within Living Labs, for instance, the four stages iLab.o Living Lab projects (with contextualization, concretization, implementation and feedback) as well as the cyclicity of these processes as evidenced in Helsinki Living Lab innovation process schema, which is critically based around mechanisms of knowledge/information management and coordination of stakeholders involvement in innovation (Almirall, Lee and Wareham, 2012), as summarised in Table 15.

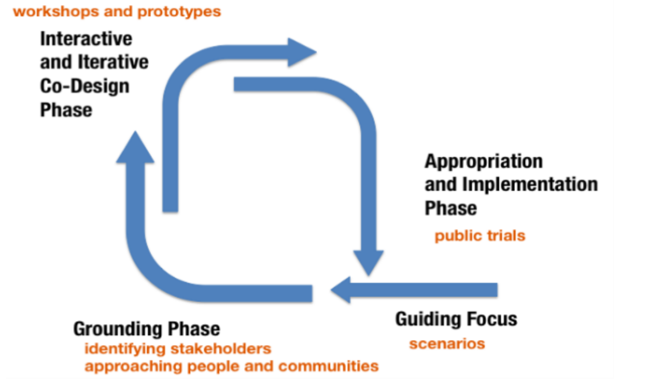
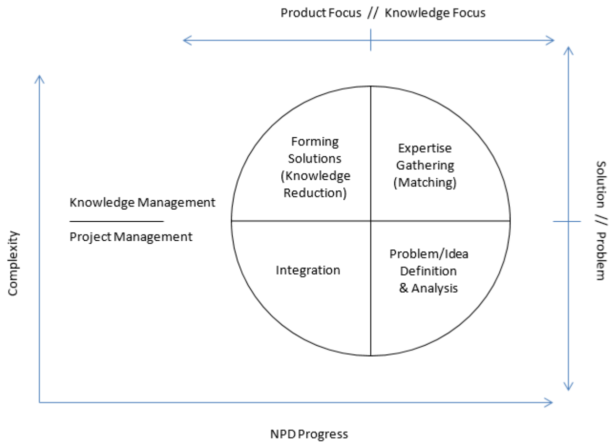
<table>
<tr><th></th><th>iLab.o living labs</th><th>Helsinki Living Labs</th></tr>
<tr><td>Case Studies from Literature (Almirall, Lee and Wareham, 2012)</td><td>1. Contextualization
2. Concretization
3. Implementation
4. Feedback</td><td>
</td></tr>
<tr><td>Proposed “Innovation Moments” Framework</td><td>1. Defining the problem/idea
2. Gathering the required expertise
3. Forming applicable solutions
4. Integrating into the developed product</td><td>
</td></tr>
</table>

Table 15 - Examples of Living Labs methodology from literature case studies compared to the proposed framework.

Micro Level-Element: Structural Absorptive Capacity

As per the MLP-GSSI approach, the micro-level analytical framework needs to focus on the socio-technical system of knowledge and technology’s “openness”. In my case, this can be best done by examining the mechanism of knowledge exchange and technology transfer across the firms' boundaries, which is the core element of the open innovation theory. One such critical theory is the notion of “absorptive capacity” (Cohen and Levinthal, 1989, 1990), defined as “the ability of a firm to recognize new external information, assimilate it, and apply it to commercial ends” (Cohen and Levinthal, 1989) and has recently been re-conceptualised as a “a dynamic capability that influences the creation of other organisational competences and provides the firm with multiple sources of competitive advantage” (Zahra and George, 2002). Given its clear applicability to understanding knowledge interaction over firms’ boundaries, the concept of absorptive capacity has also been explicitly linked to open innovation by many authors (Huang and Rice, 2009; Spithoven, Clarysse and Knockaert, 2010;

Bogers and Lhuillery, 2011). However, despite definitions to the contrary, the vast majority of research so far has looked at the absorptive capacity as a property of a firm, acquired primarily through recruitment of skilled workforce and prior knowledge (Marabelli and Newell, 2014). Only recently, studies looking beyond such notion of "possession" of absorptive capacity, and merging it with the complementary understanding of "practice", as previously proposed by some authors (Marshall and Rollinson, 2004), in particular as practices and routines for recognising, assimilating, transforming and exploiting external knowledge (Zahra and George, 2002; Sun and Anderson, 2010; Marabelli and Newell, 2014). Furthermore, extending these descriptors to ask "processual-structural" questions related to absorptive capacity, i.e. how and what learning takes place (Vasconcelos *et al.*, 2018), leads on to (partly) focusing on absorptive capacity as an organisational routine, acquired through processes of social/organisational learning (Lewin, Massini and Peeters, 2011). Deploying these concepts to sensitise firm's organisational processes underpinning absorptive capacity within new product development and examining how the organisational learning takes place in order to build a firm's processual absorptive capacity – clearly a critical component of SMEs open innovation behaviour – forms promising analytical framework.

Towards a Unified Theory of Innovation?

Overall, in comparison to most other proposals (Bergek *et al.*, 2008), the combination of MLP socio-contextual approach and the instrumental deployment of geographically-bounded SSI methodology, i.e. an MLP-GSSI, define a more consistent and comprehensive framework, focusing on an in-depth analysis of the development of STSKT, the networked behaviours of the key groups of actors, and policy/economy driven institutional regimes, whilst interpreting these elements through specific analytical frameworks. By applying the symmetrical multi-level understanding of the three building block elements, the understanding of socio-technical assemblages (STA)/SSI is critically theoretically strengthened.

In case of Open Innovation transition examined here, the outlined co-evolution of STA/SSI layers-elements, the macro-level institutions (e.g. geo-sectoral innovation policy), meso-level networks of actors in experimentation and learning (e.g. within Living Laboratories), and the micro-level socio-technical systems of knowledge and technology (e.g. developed and reconfigured through structural absorptive capacity), will be easier to trace under these circumstances. In particular, clarifying the key level perspectives and the linkages between them, such as the typologies of innovation intermediaries interventions and the boundary object-sensitising concept of innovation moments, can form an analytical framework cutting across the traditional STS-IS and macro-micro divides, which is helpful in developing deeper understanding of transitions in innovation culture, for instance, the current emergence of open innovation. However, other analytical frameworks can be constructed within the same interest area, depending on the focus of the proposed study – here our interest was in the interconnectedness of actors within the open innovation transition. With studies focused on different interests, for instance, the expansion of the analytical interest beyond primary actors (i.e. innovators), novel approaches to the study of SSI have emerged, such as analysis of the innovation by demand vs other innovation (Adams, Fontana and Malerba, 2013) and dynamics and evolution of sectoral systems and sectoral system taxonomies (Malerba *et al.*, 2016). I argue that these, too, could benefit from further contextualisation within an MLP-GSSI framework, though with a different set of analytical priorities.

In my case, I argue that deploying the resulting MLP-GSSI framework contextualised for open innovation can lead to further understanding of the studied geographically-bound sectors' performance and further developmental opportunities for its actors as well as framework's fine-tuning. In the example I presented, this should be based upon a detailed understanding of the overall typology and contextual application of innovation intermediaries interventions, the ability to discover and deploy enabling contexts for living laboratories, and the insight to encourage the organisational learning behind the development of structural absorptive capacity. However, it is important to note, that the MLP-GSSI framework and its adoption to the open innovation transition, as presented in this paper, is not to be read as a normative policymaking tool. As noted by Genus and Coles:

> *"there is a danger that some of the ideas implicit in this treatment of the MLP can seep into the policy making domain so that the 'reality' of a neat, mechanistic model of transition could become the dominant interpretation of the MLP"* (Genus and Coles, 2008, p. 1444)

As such, whilst I hope having the MLP-GSSI framework for OI analysis would be helpful to any actor involved in managing transitions towards an open innovation-type system, this framework is not, and cannot be, a recipe as to how one could be started or an overall snapshot view as to how they play out. Any insights included in this paper are there to address the development of the understanding of the theoretical/analytical framework, which has to be empirically deployed to give any useful results to analysts or practitioners.

In conclusion, this paper proposed MLP-GSSI framing of the intersection between the macro-, meso- and micro- levels-elements and innovation theories within the broader socio-technical context of open innovation transition. With this multi-dimensional approach, I am hoping to, on one hand, further the understanding of the geographically-bound sectoral dynamics as well as, on the other hand, expose opportunities for actors to (further) engage with these developments. However, in order to study comprehensively the phenomena that emerge across the established elements-levels and links within the framework, a new methodology needs to be developed and deployed. In particular, taking inspiration from multi-sited longitudinal studies developed through the Biographies of Artefacts and Practices approach (Pollock and Williams, 2008; Hyysalo, Pollock and Williams, 2016), I propose that multi-method "participatory strategic ethnography of innovation" is required, which explores, in particular, the cross-level translation of socio-technical trends (Vidmar, 2019d). This can be achieved, for instance, by studying "innovation moments" by examining the innovation processes combined with (social) network analysis within places of innovation (e.g. SMEs, firms, laboratories, etc. depending on study) and examination of policy contexts and their operationalisation through innovation intermediation (e.g. policy content and its development, organisations involved in deployment, etc.). This new methodological advance is crucial for a variety of broad-base innovation research projects, which are attempting to examine multi-level geographically-bounded sectoral systems of innovation transitional dynamics.

Chapter 8: The PERIpatetic Approach - On Becoming an Uninformed Insider

Introduction: New Approaches for New Modes of Research

In this paper, I am outlining my reflections on the changing nature of social-scientific enquiry and the related re-calibration of researchers' philosophical framework, as expressed in the case of my research into the development of the Space Sector in Scotland. This is a culmination of half a decade of engagement with the studied community and resolving critical practical and theoretical challenges. In particular, I have been working on a problem-solving-driven study, as well as conducting it in close cooperation with collaborators in the field, having been embedded within an innovation team at a leading research organisation. Put together, I argue that the set-up of this work reflects a new methodological framework of the "PERIpatetic Approach" - a Practical Epistemology for Researching Innovation (PERI). The acronym PERI also (sub-)refers to the ambition that the philosophy behind the PERIpatetic Approach is based on Perspectival, Embedded, Responsive and Introspective research principles.

To begin with, the "common wisdom" on the epistemological, methodological and practical set-up of social-scientific research is fast departing from the "established norms" of 20th-century sociology. Of particular interest for my work on multi-level perspective on Open Innovation is the engagement with professional elites in the scientific, policy and business communities and the changing role of the researcher in this environment. The key notable trends within it are the emergence of abductive/problem-solving epistemologies, in-depth long-term/longitudinal presence, deployment of mixed methods and extensive reflexivity. These changes crucially bring about a different set of requirements on the researchers in terms of their positionality when accessing and investigating such environments, which are critically understudied (Berger, 2015). Though primarily based on my own personal experiences, I believe my reflections and conclusions here apply much more broadly in a variety of social scientific enquiries in professional environments, in particular in contentious or high-stakes areas and in work identified as participatory action research (McIntyre, 2007).

In particular, many authors have noted the (increasing) importance of "insider" status for research within professional elite settings. In fact, even the proponents of the "informed outsider" approach directly acknowledge: "researcher has the insight of an insider but the neutrality of an outsider" (Welch *et al.*, 2002, p. 625). However, my experience and observation tend to contradict this conclusion – the researcher can never really have the exact same insight of an "insider", nor can they be as neutral as an "outsider", having committed to a close-quarters longitudinal research project. I argue, that with a new research paradigm(s) emerging, focusing on more detailed and prolonged multi-sited ethnographic studies, the researcher's positionality is realigning away from the "informed outsider" approach, outlined by Welch et al. (2002) and towards an "uninformed insider" approach, based on meaningful engagement and embeddedness in the studied environment, yet retaining the critical analytical distance. Such closer relationship acknowledges the need for a significant amount of trust required for access to, and maintenance of, prolonged engagement with the professional elite, whilst recognising the inherent knowledge asymmetry in this relationship and accommodates more inductive/abductive information gathering and knowledge co-construction (Morrisey and Morrissey, 1998). My solution to this challenge is to "embrace" the position of an "uninformed insider", acknowledging a degree of limitation in our insight and a degree of partiality. This researcher position is also much more closely aligned with my adoption of abductivist epistemology, i.e. the bottom-up problem-solving approach to build theories, where researchers deliberately ensure that they enter the field with as little prior knowledge as possible, in order to truly recognise all points of contention and hence limit any bias. I further argue that this is a recognition of existing practices, to both further establish the trust between the various stakeholders and increase confidence in research processes and findings.

Specifically, this article outlines an open-ended interdisciplinary participatory and problem-driven approach to empirical work. It begins by presenting the foundations of my ontological and epistemological position – the PERIpatetic Approach – and outlines the empirical context in which my research was conducted. Then, it examines, in turn, my reflections on the four key aspects of the PERIpatetic Approach, in particular, the methodological principles behind participatory strategic ethnography of innovation, the "uninformed insider" positionality, abductive analytical work and ethical introspection. Finally, I discuss the three stand-out elements of my experience of deploying the PERIpatetic Approach as an "uninformed outsider": a) the importance of becoming an insider by building trust and gaining access to the community, b) the importance of "uninformedness" for deploying the strategic ethnography and using abductive research epistemology, and c) the dynamic and fluid nature of this philosophy and researcher's position.

My Philosophical Position – The PERIpatetic Approach

Though peripatetic philosophy has a strong historical resonance, as it is often used to denote the Aristotelian approach to conceptual development and pedagogy, its direct meaning of "walking about" is a very suitable symbolic summary of the break with the "traditional", more dispassionate and "static" research philosophies deployed in innovation studies. Specifically, often borrowing insights from more close-quarter anthropological studies, a bigger array of ethnographic methods and a move towards situated empirical sites are changing the way in which research is designed and conducted. Through my work within this field, I have been particularly drawn to examining multiple perspectives and deploying a mix of different methods, all grounded in being in a constant and close relationship with the key participants in the field - the gatekeeper organisation.

This approach seemed to resonate with well-established epistemological positions in sociology, in particular, such as participatory action research (McIntyre, 2007) and abductivism (Blaikie, 2004). However, the predominantly single-sited methodological set up within these enquiries often lacked the multi-perspectival flexibility I required. Here, I was inspired by the Biographies of Artefacts and Practices (BOAP) Approach (Hyysalo, Pollock and Williams, 2016) putting forward a more strategic view on ethnography, by focusing on following subject matter across a multitude of sites and deploying a variety of methods. Combining these two starting points, I argue that a new comprehensive framing is required, formalising the peripatetic nature of contemporary innovation research.

Hence, I propose the PERIpatetic Approach as a way forward, combining four elements to bring together a practical epistemology for researching innovation (PERI), fit to match the advances in the mode(s) of social science research as well as the evolution of the subject-matter fields. It combines the interest in multi-perspectival knowledge-making, acknowledges embedded researcher's positionality, applies responsive analytical framework and deploys introspective mechanisms to legitimise its findings (as presented in Table 16). These four elements are in dialogue with the original tenets of the Strong Programme of Sociology of Scientific Knowledge (Bloor, 1991), in particular aiming for causal explanations, impartial position, symmetrical analysis and applying reflexivity to our work.

Strong Programme Tenet	Brief Description	Dimensions of the PERIpatetic Approach	Research Theory and Practice
Causality	it examines the conditions (psychological, social, and cultural) that bring about claims to a certain kind of knowledge	**Perspectival**	***participatory strategic ethnography of innovation***
Impartiality	it examines successful as well as unsuccessful knowledge claims	**Embedded**	*action research via* ***uniformed insider***
Symmetry	the same types of explanations are used for successful and unsuccessful knowledge claims alike	**Responsive**	*abductive epistemology with critical realism*
Reflexivity	it must be applicable to sociology itself	**Introspective**	*ethics-reflection-acknowledgement.*

Table 16 - Breakdown of PERIpatetic Approach, built on Strong Programme tenets.

Firstly, the PERIpatetic research is moving away from producing causal generalisations and towards describing perspectives by recording and analysing narratives, developing concepts and integrating individual accounts into community-wide trends. It is particularly concerned with nested multi-layer contexts and is grounded in researchers' experiences, rather than a priori intellectual project. This is a significant departure from the past normative interest in causality, which could be attacked either as inherently positivist or when interpreted through relativism/constructivism, it may be seen as lacking in auto-reflexivity (if scientific knowledge is socially conditioned, then social scientific knowledge is also socially conditioned, hence correlations are only pertinent to the specific context, rather than truly "causal").

Secondly, by being closely embedded in the field, a PERIpatetic researcher is an active co-creator of the studied environment and develops a level of presence and interaction akin to a field's "insider". The applied and empowering nature of action research is in stark contrast with past notions of researchers' impartiality, though it is more in line with both the de-facto influence we have in the field as well as the current (political) agenda within social science, including innovation studies, to create meaningful and impactful research. However, in order to obtain legitimate and credible findings, strategies for data collection must reflect intellectual independence of analytical work, perhaps through enacting "uninforemedness".

Thirdly, the epistemological position thus developed combines field insights, in particular, input about challenges and interests of the various participants, with an iteration of a multitude of viewpoints. Hence, the PERIpatetic approach is adopting an abductive epistemological position, i.e. deriving theoretical models from interrogating empirical data through a real-life problem-solving process. Thus, it is less concerned about the traditional measures of theoretical coherence, for instance, the symmetry of explanations, and more focused on being responsive to the effect of the proposed models. This is consistent with the critical realism approach to accept knowledge claims validity through their application rather than derivation.

Fourthly, the PERIpatetic Approach fully adopts and extends the importance of the researcher's reflexivity through a clear and comprehensive introspective process. Specifically, when working embeded in the field of study as an active participant, applying abductive epistemology and collecting data via participatory methodology, the understanding of positional challenges and intellectual biases is vital. A three-stage framework is suggested here: having a rigorous ethics framework, engaging in constant reflection and (publicly) acknowledging the participatory action nature of such work.

Later, each of these elements will be examined in greater detail but in order to provide some context for the analysis of their deployment, the next section first outlines the empirical environment I encountered through my research of the evolving networks, practices and institutions in the emerging Scottish (New) Space Sector.

My Time with the Scottish (New) Space Sector

The makeup of the Scottish (New) Space Sector is very appropriate for intensive qualitative and quantitative research of innovation processes and associated "culture", i.e. the social phenomena related to techno-scientific and economic development, which was the subject of my research. This is due to:

- A good mix of the different types of actors (upstream/downstream, software/hardware, spin-off/start-up)
- Manageable size for complete study: currently <20 SMEs with <200 employees
- Strong research base (in particular Dundee, Strathclyde and Edinburgh Universities) and highly educated workforce
- Strong institutional presence (university tradition, many institutes and research stations

- An existing rich historical context in science, technology development and innovation (in particular through Scottish engineering legacy)
- Significant current political and economic interest, noted in particular in roadmaps adopted by the UK government - 8 Great Technologies (Willets, 2013), Space Innovation and Growth Strategy (Space IGS, 2010), Health and Size of the UK Space Industry (UK Space Agency, 2014), etc.
- Predicted and part-evidenced rapid growth at a major industry transition

My research has benefited from a specific time context, linking the past and present (and looking into the future). Whilst studies of innovation are by their nature historical, the significant (political) emphasis on technology/knowledge transfer and commercialisation of scientific research is a very contemporary concern (Nutley, Walter and Davies, 2007). This was helpful both in terms of there being a significant appetite for collaboration from different research institutions, an increased openness (due to perceived benefits) on the part of the Space “community” and a generation of a significant amount of documents, events, discourse and literature.

Crucially, the Space Sector is currently undergoing a major transition (Adlen, 2011), which is bringing the issues of innovation and technology transfer, as well as changes to all levels of its structure, into focus. For the abductivist and participatory action research rationale this proved very fruitful, as problems and questions of understanding are emerging in the field and various stakeholders became increasingly open and interested in working with me to develop new knowledge and solutions. As a way in, I benefited from having studied natural sciences (Physics and Astronomy, with specific interest in technology development for scientific research) in my first degree, and have developed close ties with the UK Astronomy Technology Centre (UK ATC), a Science and Technology Facilities Council (STFC) (now part of the UK Research and Innovation) establishment, which is the national laboratory for development of Astronomy instrumentation, located at the Royal Observatory in Edinburgh (ROE).

Having had a prior interest in science and technology policy and philosophical, socio-political and economic aspects of techno-scientific development, I professionally transitioned into Science, Technology and Innovation Studies (STIS) research, though I retained these previous associations and contacts, as I was particularly interested in working within the fields I already knew and understood. In particular, through both public engagement as well as research activities, I was specifically well embedded in the Astronomy and Space Science work in Edinburgh and in Scotland. Approaching the UK ATC with an initial interest to work on an abductivist participatory research in this arena led to a research partnership agreement, which enabled me a longitudinal embedding in the field by becoming an informal member of the Innovations team and colleagues there to be my gatekeepers for further access to stakeholders.

Additionally, my abductivist problem-solving agenda was well met by my research partners, as through the development of the Higgs Centre for Innovation, a key new part of UK government's investment into the Scottish New Space sector, which was being built and is operated by UK ATC at ROE, coincided perfectly with my project’s timeline. As part of this significant undertaking outside of the innovation’s team “normal operation”, several significant questions and challenges emerged, with an acute need emerging to understand the multi-layered and complex landscape in which this new Centre needs to be successfully introduced. Having so easily found a significant source of interesting starting points for what shaped up to become my active participatory research into innovation culture within the Scottish New Space Sector, I designed a research project to match my overall interests, inspired by problem-solving demand, found in the field (broad alignment with the PERIpatetic approach elements is summarised in Figure 21).

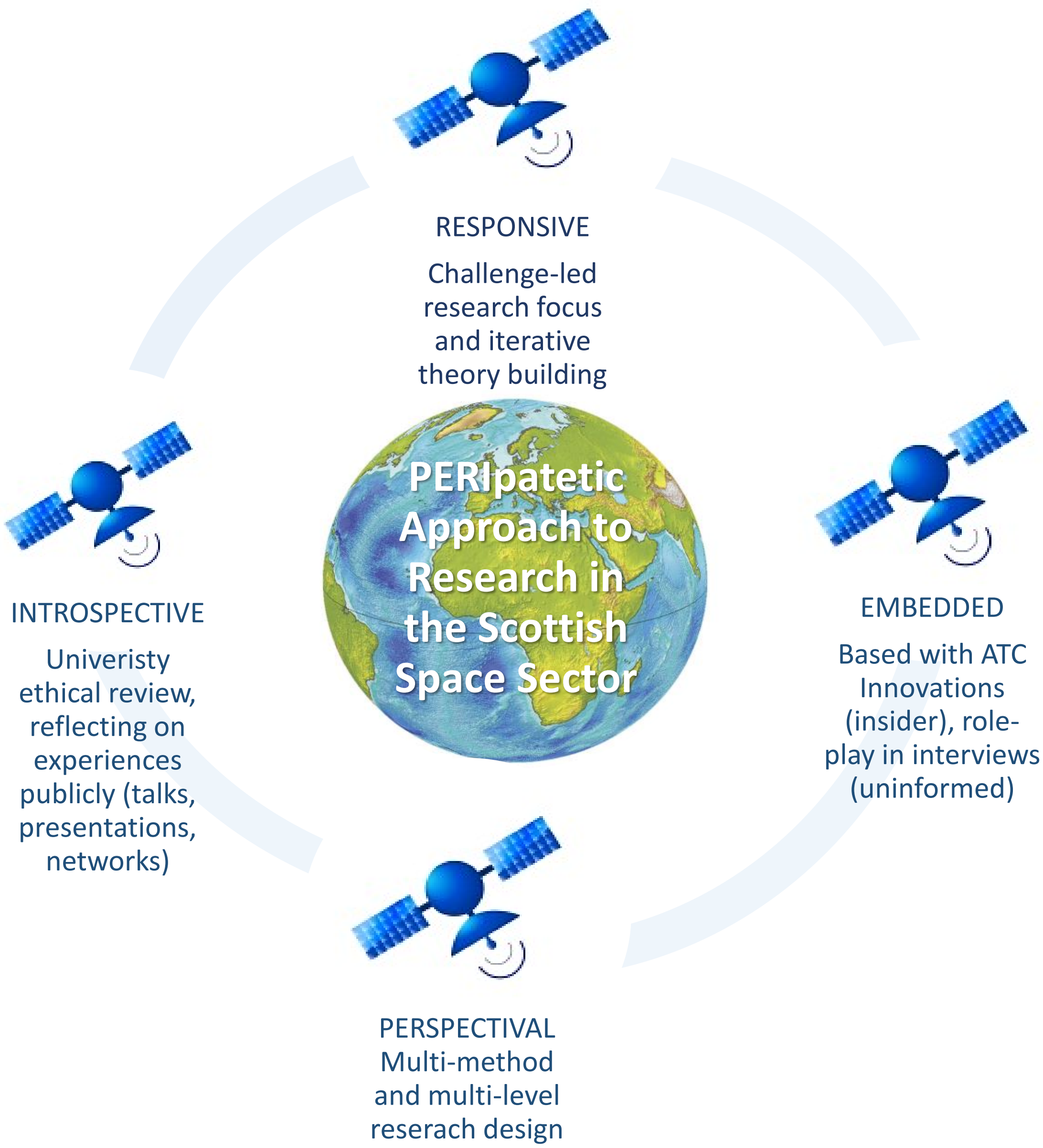


Figure 21 - Relational positioning of the different frameworks within the empirical work.

The first stage of my research project concerned the embedding in the research partner's team, framing of the enquiry by "abducting" a set of research questions and developing methodological and theoretical framing for my study within a pilot setting. Crucially at this point, only the micro-level of the analytical approach was being developed, as in abductivist setup, design flexibility must be ensured to be able to respond to early findings and their reception by the study's participants. In my case, it turned out that the first phase validated methodological standpoint and theoretical framework for this part of the enquiry and pointed towards a second stage roll-out of micro-level data collection, as well as exposed key additional questions (moving from micro- to meso- and macro- levels) to be examined analytically in the second stage. Consistent with other modes of research design, working through the first stage also involved an extensive review of the existing literature and an in-depth analysis of the subject-matter (the Space Sector)'s background framing.

In the critical second stage, a detailed qualitative enquiry was undertaken to assess not only the descriptive narratives emerging from the empirically available ethnographic data collected in the first two stages but also to develop a set of new theoretical models and framings. Specifically, these concerned the understanding of micro-level changes to innovation processes and practices, meso-level innovation networks emergence and structures, and macro-level geo-sectoral policy and its translation through innovation intermediation. These theories were iterated with the help of research partners and were being deployed as key pieces of new understanding in order to solve their real-life problems of establishing a new innovation centre and integrating it into the existing ecosystem. From a participatory action research standpoint, the timing of this study is very conducive to have a really meaningful impact on the researched community as findings are available right from the start of the Higgs Centres of Innovation programme (in Spring 2018), meeting less entrenchment of practice often present in more mature projects (Zeitz, Mittal and McAulay, 1999).

Having thus set the scene, in the next four sections I analyse in greater detail my experience with the four research principles of the PERIpatetic Approach - being Perspectival, Embedded, Responsive and Introspective researcher - and highlight the features of the emerging participatory strategic ethnography methodology and my "uninformed insider" positionality.

Perspectival: Participatory Strategic Ethnography of Innovation

Learning from the Biographies of Artefacts and Practices (BoAP)

The Biographies of Artefacts and Practices (BoAP) perspective (Pollock and Williams, 2010) emerged amongst an informal community of scholars seeking to move away from the atomistic perspectives and 'snapshot' studies of particular moments of technology design or use (Hyysalo, 2009; Pollock and Williams, 2010; Williams and Pollock, 2012). The key premise is to go beyond the single-site case-study or actor-centred accounts that prevailed within recent STIS research and develop more effective methodological templates based upon a longitudinal and multi-site study in the shape of a "strategic ethnography" (Williams and Pollock, 2012). BoAP's aim is to evolve a practice more appropriate for effective research of systemic cultural nature (of innovation processes), which can produce findings refuting Science, Technology and Innovations Studies field's recent tendency to accept 'flat' ontologies (i.e. lacking temporal and spatial depth and/or analytical clarity of any generalisable phenomenological structure, beyond the apparent descriptive accounts).

Ground-breaking longitudinal studies within the BoAP perspective detailed the complexity of innovation processes, involving diverse arrays of players (engineers, users, managers) interacting over protracted periods and across many locales. Work conducted within this perspective has highlighted the various ways in which users contribute to the development of products and the role of various forms of innovation intermediation which may bridge contexts of technology supply and use (Williams and Pollock, 2012). As BoAP authors recently pointed out:

> *"Every research design involves choices about where to address research effort. New sites and relations become visible in the course of fieldwork. […] This calls for flexibility in research design coupled with the willingness to keep on pursuing the line of investigation beyond the single setting and project funding."* (Hyysalo, Pollock and Williams, 2019)

The Biographical Approach to the Study of Systemic Features of Innovation

Empirical work of this type can only be done in a more "engaged" manner; hence, researchers such as myself have moved away from the "one-way" econometrics and survey-based approach traditionally used in Innovation and Business Studies (Markman, Siegel and Wright, 2008). It is important to note that this is not a break from those key methods used in these fields; rather it is adding the depth to (meso- and macro- scale) quantitative data by interpreting it through (micro-scale) qualitative analysis, leading to more holistic mixed methods approach. For instance, my methodological set-up is built around three methods, the main being: quantitative and qualitative (secondary) data/document analysis, qualitative data from interviews, observations and surveys, and (auto-)ethnographic reflection (Sedlack and Stanley, 1992; Richards, 1996; Odendahl and Shaw, 2002; Delamont, 2013; Bryman, 2016). Hence, I have labelled this collectively as "participatory strategic ethnography of innovation", being a systematic longitudinal iterative study of the culture of innovation building on a multi-perspective and multi-level enquiry and accentuating the fact that it is moving away from the prevalent research paradigm in Innovation Studies, which predominantly relies more on quantitative data and fast-paced or “snapshot” data collection.

As such, this research project is also moving the BoAP methodology into a new direction – towards understanding systemic practices and artefacts, instead of specific ones. In particular, the aim of this research was to map out a multi-level perspective on the emergence of innovation systems through the prism of open innovation transition (Vidmar, 2019a). Methodologies for dealing with the study of systemic elements in the macro-level context are well developed (and contested) within the Innovation Studies literature. In particular, a very successful paradigm, namely Innovation Systems (IS), has been noted for its limited reach in terms of addressing the social phenomena in innovation (Williams and Velasco, 2016).

For instance, linking those top-level approaches to specific instances of innovation in actual product development is methodologically underdeveloped. To bridge this gap, I proposed that the main unit of analysis in the first part of my research is an “innovation project”, i.e a development of a (single) product within a studied SME, and then analytically move to meso-level network of actors well as macro-level policy (Green *et al.*, 1999). Epistemologically, this also follows the CEN/TS standard for innovation management (CEN, 2013), which is distinguishing between “specific innovation projects” and “general innovation management”, and the Oslo Manual (OECD, 2007a) separating “object” and “subject” approaches: the “object” approach is based on a single business innovation project, e.g. the development of a new product; and the “subject” approach, which looks at a firm in its entirety. Specifically, this enabled me to link SMEs’ behaviour in innovation process management, rooted in specific examples of new product development, and the network interaction, based on acquired practices. To turn an “innovation project” into an understanding of the innovation processes and their dynamics requires a strategic ethnographic methodology, which enables a reasoned selection of several ethnographic research components and mixed-method analysis to perform a longitudinal study of innovation as a socio-technical phenomenon. Of particular interest is a multi-level understanding of the changes in the development of new products due to network mediated inputs from external partners and ways in which organisations performing new product development responded to the engagement of external sources of knowledge, be those the lead customers, academic researchers, or the wider market. More specifically, recording and analysing the changing structure of new product development processes and the co-creation of collaborations within the innovation networks were the main targets of the first part of the study, though their interpretation hinged on policy-level dynamics, inter-organisational relationships and learning and the operationalisation of innovation intermediation (the latter was examined in the second part of my study).

Beyond the Single Object of Study

This means that in practice, the variety of data collected is organised in a series of case studies, joined together into a broader multi-sited and temporally extended case study (Yin, 2009) - addressing the emergence and evolution of innovation practices and routines. Such research clearly features a multilevel design structure (see example in **Error! Reference source not found.** below) whereby individual accounts (actor's experiences) are integrated via organisational narratives (companies) further into regional sectoral dynamics, which are of course part of an even wider national and international/global landscape. In these higher-level frames, micro-level social science within professional communities of practice becomes

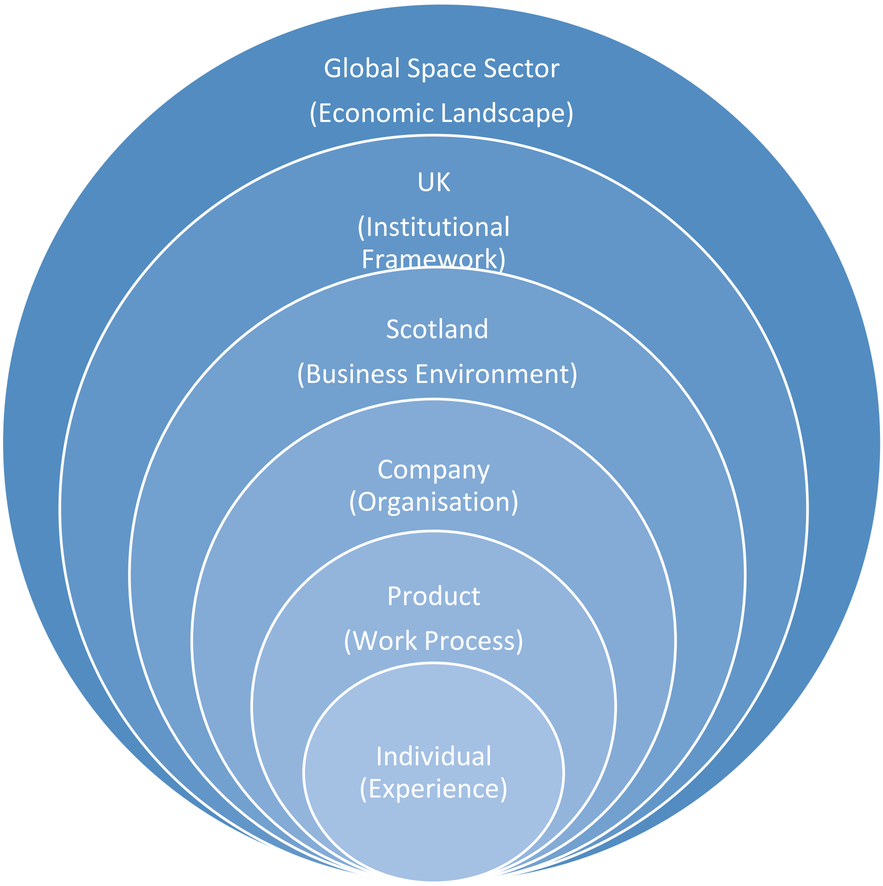


Figure 22 - The ontological underpinning of a multi-level epistemology as applied to my research of the (New) Space Sector in Scotland.

linked with econometrics, policy and politics and legal frameworks, hence leading to a much more complete picture of the studied environment.

However, studying innovation in SMEs is challenging due to several factors, such as short timeframe, unclear boundaries, the informality of operations and access difficulties. Hence, as noted above, this type of research can only be done in much closer proximity to the studied community, in order to gain access to all relevant data and informants and develop a longitudinal and multi-sited overview of transformation and change by being present as it (gradually) occurs. Having undertaken an abductive participatory action research project following the strategic ethnography from BoAP methodology within the Scottish (New) Space Sector over the past five years, I have developed a clearer view of how this novel way of research has transformed the researcher's position within the studied field and how those of us championing this mode of scientific enquiry should approach our research design, what challenges we might be facing and how to avoid certain major pitfalls. Hence, in the next section I briefly outline my "uninformed insider" positionality as a PERIpatetic researcher, which will also be analysed in greater detail in the discussion.

Embedded: The "Uninformed Insider" Approach and Action Research within a Professional Elite

When researching a niche or small professional environment, such as my work studying innovation in the Scottish Space sector, it is often the case that most, if not all, of the actors - research subjects - are found to be (inter)connected in some way (Odendahl and Shaw, 2002). From a methodological point of view, this has several benefits, for example, it is easier to find research participants and the needed data. However, there are several cons, too; a breakdown of trust with one of the participants can have significant repercussions across the whole community, and first impressions are important to gain "admittance". Hence, when planning and carrying out research, one has to be very mindful of the power structures and "positioning" of the researcher in the context of the studied community (Mikecz, 2012).

In my case, some of these issues were mitigated from the start by opting for a collaborative research project, working closely with a prominent organisation in this sector, namely ATC Innovations, of UK Astronomy Technology Centre (UK ATC), a national laboratory in the portfolio of the Science and Technology Facilities Council (STFC). Though this addressed the issue of access it created new problems in terms of my identity in the field. Being an academic researcher, embedded within UK ATC, who I have worked with before as a Physics student, puts me in a somewhat privileged, yet very complicated situation, which epitomises the tension traditionally experienced by STIS scholars, many of whom are social scientists, with a natural science background, studying the very professional elite they have once been (or aspired to become) a member of.

Consequently, this means that the access into the field and the design of the data collection (in my case mainly interviews and surveys, but also participant observation and ethnography) must address two significant challenges within research design: the interviewees are author's peers (in terms of "shared knowledge and/or understanding") or even social superiors (hierarchical status) (Platt, 1981) and they represent different types of (professional) elites (Mikecz, 2012). In gaining entry into such an environment, it is useful to mention one's natural science credentials and association with reputable organisations in the field, in my case an Honours Degree in Physics and my collaboration with the ATC Innovations. This establishes the researcher as the member of the same professional elite – as "one of us" or a "peer". However, my professional and social standing in this elite is precarious at best, as I was a junior researcher and approaching the subject from a social scientific point of view, including using "alien" social science methodology. Consequently, there is a clear power hierarchy, and I was at the bottom of it!

I propose that this issue is best addressed by a split approach to the interview, whereby I played up my credentials to organise the interview and establish trust with the informant (Welch *et al.*, 2002; Mikecz, 2012). However, I later suggested to the interviewee to enact a "role-play" of a lay interviewer with the peer interviewee (Platt, 1981), giving myself an alibi for exposing my true ignorance of some of the particulars, whilst at the same time subtly demonstrating mastery of the conversation and key topics. Exhibiting the latter quality is particularly important as the interviewee will likely be assessing the "intellectual legitimacy" of the interviewer (Platt, 1981), and by extent the researcher's collaborating organisation. Background information about the research (type, format, institutional connections, topic, etc.) was provided to the interviewees (to establish intellectual connection) prior to the interview (Platt, 1981), but not the (theoretical) assumptions, predicted outcomes or any provisional results, which will ensure that the respondents do not attempt to "assist" the interviewer in providing the "right" answer (Haidt, 2012). This was enabled by the interview format, which is very open-ended, hence preventing codifying any intentions (Harvey, 2014).

Before entering the field, I considered that this positioning was best summed up as the “informed outsider” technique (Welch *et al.*, 2002), whereby the interviewer positions themselves as being a well-informed yet non-expert observer of the studied subject (or group). This technique is widely used in journalism, however, it is also an (increasingly) prominent feature in parts of social-science research as well, particularly in projects dealing with professional elites, such as research in science, technology and innovation studies (Stephens, 2007). However, the more I reflectively examined the “informed outsider” position, the more I became convinced, that in truth, I was more of an “uninformed insider” than the other way around.

Though the design and the actual experience of the interviews were close to Mikecz’s (2012) own experience which he describes as

> *“my positionality has been somewhere in the middle on the “insider–outsider” continuum. Perhaps the term “concerned foreign friend” would describe my position in this research best. I am not perceived as a local but I am not viewed as an outsider either.”* (Mikecz, 2012, p. 490)

My overall experience of positionality would be best described as an intern or a new member of staff, who is accepted and trusted as a (new) insider in the professional community, also having some relevant background knowledge, though is assumed largely ignorant of the nuances and details of the goings-on. This experience is also very consistent with my interview strategy of “role-playing” lay uninformedness, to ensure as complete and unbiased as possible data collection, after having established access and trust based on institutional and personal credentials by (insider) association. This position, however, comes with specific ethical considerations and risks, which have so far not been consistently documented or well understood. In particular, the key considerations are to do with, on one hand, reputational risks to the researcher and their academic impartiality through bias and conflict of interests, and on the other hand, reputational and other risks to host and partner organisations, by dealing with sensitive information and association with the research project due to the embedded insider context. I turn to strategies to address these issues later, after first exploring abductive critical realism ontology and highlighting additional ethical challenges of potential bias.

Responsive: Abductive Epistemology with Critical Realism

Through research design and empirical practice, I established my epistemic position as a critical realist doing abductive research (Blaikie, 2004; Ong, 2012). Such research framing starts from researchers' immersion in the field and interaction with a variety of actors in their environment in order to identify an existing "problem" (of understanding) and subsequently applies and builds a theoretical framework to answer it, supported by collecting and interrogating empirical data. This is distinct from both (traditional) deductive approach, which is characterized by defining theoretical framework upfront and proving it by empirical research, as well as inductive (grounded theory) approach of focusing entirely on (empirical) theory development from collected data (Thornberg and Charmaz, 2012). The issues found within these two distinct approaches are two-fold. On one hand, deductive modes of research are often out of sync with the needs and realities of the studied field and produce less applicable and impactful findings. On the other hand, the inductive approaches often ascribe too strong a value to specific situated and contested data, leading to either narrowly localist findings or largely descriptive accounts.

In addition, abductive reasoning has been recently shown to be compatible with the critical realist position, through being justified on the grounds of optimality (Schurz, 2018), concluding that

> *"[…] we can argue that by performing abductive inferences we always take the advantage of explaining and representing our system of experiences by the best available theoretical model, i.e., by the most simple and most unified theory. […] Should some part of our theoretical model be false, one of two cases may obtain. Either we observe this in the form of an incorrect prediction; as soon as this happens we will take steps to correct our theory. In other words, abductive inferences are self-corrective and have an inbuilt learning ability. Or we never observe it (because our experiences are limited); then nothing happens and we continue to operate with an instrumentally optimal theory, although it is false, but in a way that cannot be empirically detected by us and, thus, will not practically harm us. Thus by performing abductive inferences to unifying theoretical models we can only gain but not lose something."*
>
> (Schurz, 2018, pp. 3894–3895)

Hence, adopting the abductivist conceptual framing, I was concurrently collecting and analysing data and reviewing the literature, with in-situ validation of the proposed theoretical framing (Ong, 2012), which leads to generalisable, applicable and meaningful answers to real pains relevant for studied field's stakeholders. Many STIS scholars have argued for similar epistemologies, for instance, Pickering describes what he terms as “pragmatic realism” (Pickering, 1995, p. 183) as “machinic performances and representational chains, and how they are aligned with one another in time”. In Pickering’s analysis, such approach is the best option for exploring “the mangle” of “resistance” and “accommodation” within the practice of scientific research and technological development, with the aim to expose the “reconfiguration and extension of scientific culture” (Pickering, 1995, p. 21).

This was also a very intuitive mode of research for me, as I previously studied in natural sciences (Physics and Astronomy) and I transitioned into science, technology and innovation studies (STIS) primarily to work on deepening the understanding of social, economic and political factors affecting the processes of innovation, knowledge and technology exchange and public engagement. These topics of interest sprung from identifying past and current issues and challenges with the effectiveness of these processes and their valorisation, both within science as well as in wider society. Such motives and questions already set me on a path towards abductive research, with further research design considerations only reinforcing its suitability, in particular with respect to longitudinal study and access to field plans.

Furthermore, in contrast to "fully-inductive" approaches, such as grounded theory (Thornberg and Charmaz, 2012), abductive epistemology does not presume that there is an unbiased "naive" researcher, which makes it very suitable for theorising participatory action research with obvious vested interests. That is not to say these interests are foregrounded, though, as by retaining an iterative inductive component, by advocating an immersive bottom-up analysis of the field to identify the research questions and then moving to a discursive theorisation and data collection, abductive epistemology is also much more suited to realist action research than the top-down deductive reasoning. The latter would in a similar programmatic research context likely work to reinforce the researcher's bias by a priori limiting the scope of the study, reducing the richness of the collected data and narrowing the theoretical toolbox available.

It is important to note, however, that such research philosophy leads to very close co-dependence and symbiosis between the researcher and the studied community. This way of conducting social science is often referred to as Participatory Action Research since it is based on extensive and active participation within the studied community (McIntyre, 2007). Such study design often contains a prolonged relationship with key partners, building trust and great depth of insight and (in line with abductivism) adopting a detailed understanding of the present issues/challenges. Though Sociology (and in particular Anthropology) scholars often consider immersive, active and participatory research a "mainstream" research position, STIS relationship with this type of research is uncomfortable due to our core experience with science being socially and politically biased (see for example seminal work of Gieryn (1983)).

The key problem for the researcher in this situation is the (degree of) compromising of objectivity in the face of going "native" in the field (i.e. adopting an inherent bias shared by the researched community). I propose to tackle this possibility in three ways:

1. *Appeal to professionalism within the community*. The researched community is a professional one, hence it is an imperative of their professional integrity to be objective in their interaction with the researcher.
2. *My Reflexivity.* Whilst some forms of bias and even "boundary work" (Gieryn, 1983) might be present in this community, I, as a researcher, have to recognise it and address it openly in my writing.
3. *Embracing the bias*. Any subconsciously remaining bias (Platt, 1981), should be, in my opinion, embraced. As this is an instance of active participatory research, I do want to hide the fact that my research has an agenda. However, this agenda is not incompatible with my ethical and scientific values, as though the research is there to describe the world in order to influence it, the potentially political decisions about the "influencing" are not taken as part of the research itself.

I believe that such an approach, to immerse oneself in the field, engage with stakeholders for a prolonged period of time and abductively develop understanding of their practices - by actively participating in dealing with their challenges - combines the best of scientific rigour and excellence with producing applicable, relevant and meaningful insight from social scientific point of view. Reflexive and analytical accounts of the experiences in the field based on these premises will be analysed in the discussion section, as I now turn to addressing ethical considerations of the PERIpatetic Approach.

Introspection: Ethics of Being on the Inside[43]

My position as a participant researcher and the nature of the studied community bring about ethical considerations due to the potentially problematic positioning of the researcher as a participant in a (politicised) business development operation, as a collaborating partner to a large research council (STFC), and as a peer/insider researcher. This carries significant reputational risks due to:

- possible perceived conflicts of interest, which could be damaging researchers academic integrity through bias and conflict of interests, and
- potential damage to the collaborating organisation by researcher's conduct to external partners.

My (partial) "embeddedness" in a key player in the sector meant access to (high-profile) actors was relatively easy, however engaging them and maintaining their trust was an even more precarious task, as any potential misstep on my part may damage the reputation of my collaborating partners. This includes maintaining good personal relationships in the face of asking challenging questions and scrutinising individuals' expertise and work practices, which can prove difficult (Ostrander, 1995). In my opinion, these considerations can be resolved with a constant careful situating of me, as the researcher, and my project with respect to the collaborating partner (STFC) and the University of Edinburgh. The uninformed insider approach allows for this by enabling the role-play of my gaining access to the field via my research partners/gatekeepers (becoming an insider), but conducting it as an (uninformed) academic. Importantly, this approach requires careful interaction with the other actors and constant revisions and improvements to my strategic positioning.

However, my collaboration with ATC Innovations could be perceived as both potentially creating a conflict of interests as well as introducing bias in my work. For instance, given my close association with the collaborating partner, it might not be unreasonable to assume a conflict of interest on my part, however, closer examination renders such concern unfounded. The key reasons for the dismissal of these concerns are, foremost, the nature of

[43] This approach is guided by the University of Edinburgh Research Ethics framework, including Policy on Conflict of interest (The University of Edinbrugh, 2002) and the School of Social and Political Science ethics self-audit procedures. Using these tools, the research project described here, i.e. "Scottish Space Sector and Innovation" PhD thesis, was approved at Level 1 ethics review as no reasonably foreseeable ethical risks have been identified.

the collaboration is significantly different from a commercial investment into a research programme, as this project is part of a mutually beneficial research partnership without any stipulated outcomes nor any restrictions outside general confidentiality of sensitive data and respective policies regarding ethics and intellectual property.

Furthermore, the research partner and gatekeeper I was embedded with, ATC Innovations/STFC, are in themselves a public body, a subsidiary of the UK Research and Innovation (UKRI), hence bound by the same high ethical standards and accountability as myself through my funding from Economic and Social Research Council (ESRC) – another UKRI council. As public bodies are mandated to be in pursuit of benefits to the society without any profit arising to any individual (save from intellectual property), no relative advantage should be gained by any party in this process, eliminating the possibility of an interest-based bias.

On the subject of introducing bias, a further challenge in all interviewing is to contextually recognise how competing interests influence the informants' points of view, both during the interview itself, as well as in data analysis. This is to ensure, with as much rigour as possible, soundness and validity of the obtained information. As such an "insider" interviewer has to be even more considerate of the smallest nuances in the tone of voice, hesitation, evasion of the question, using a specific turn of phrase, sarcasm, or statements with double meaning when answers are given (Knapp, Hart and Dennis, 1974). However, such issues are not unique to "insider" positionality, it is a feature in all social-scientific research and is always a complex and challenging balancing act of examining, extracting and assessing obtained data.

As outlined earlier and explored further in the discussion, using the positionality of "uninformedness" was a great asset here. By engaging in a role-play, I tried to abstract my "insider" status from the data collection exercise, and hence encourage as much as possible the expression of a un-altered point of view by the participants. I have then used iterative abductive epistemology approaches to analyse the data through narrative examination, in particular by contextualised trend analysis. This, however, does not remove all bias, in particular as related to overarching framing of the inquiry, due to embeddedness in the field. Hence, proponents of participatory action research approach sometimes suggest the acceptance and acknowledgement of such partiality as a means to effect change (Lundy and McGovern, 2006).

In parallel to addressing the concerns regarding academic (im)partiality, due to the nature of the data collection environment (i.e. a very competitive business sector), special care was taken to ensure this project protects commercial sensitive data collected from informants as well as from collaborating partners. I considered this as my ethical obligation towards the interviewees, as my research should create any undue advantage or disadvantage to the informant. Though there were no questions asked about any specific intellectual property or product feature, some information about specific products and their development and the companies' business partners was being collected. This issue was discussed at length with the informants prior to the interview, to ensure the informants were comfortable with the steps taken to protect the sensitive information. The two key steps were:

- After the interview, data was carefully extracted from the data matrix with the removal of any identifiable features of products, companies or people (which could trace the information supplied back to the company or person who supplied it).
- Additionally, all other parties mentioned in the conversation were also anonymised, with the exception of some key players due to their unique position. (There is, after all, only one national (UK) and one European Space Agency.)

Even for a very immersive research mode, like the one outlined in this paper, I believe informed participant's consent is vital. As per standard University of Edinburgh procedure, an information and consent form (see Appendix G) has been issued to all participants, read and signed by them, counter-signed by the researcher and deposited in my personal archive. The form also offered an option of choice of the level of anonymity - general anonymity of participants was ensured as standard, however, in case a quote of significant importance would arise from the interview, the researcher reserved the right to use it when presenting research findings. Participants were offered to opt-out of this arrangement (by ticking a box) and be granted complete anonymity. Very few informants selected this option, which indicated that they were happy to "be on the record" with their answers. This further confirmed my belief about their participation being professional in its nature, agreeing with my previous assumptions about their answers being full and honest, and all relevant substantive data being provided verbally.

Discussion: "Not all who wander are lost!"

In the above auto-reflexive and analytical account of my initial conceptualisation and in-the-field experience of abductivist participatory action research of professional elites with the Biographies of Artefacts and Practices-inspired participatory strategic ethnography, I have been guided by and/or have noticed three key elements which underpin my application of the PERIpatetic Approach as an uninformed insider. These three key elements are:

- The crucial role of building trust and a meaningful relationship with the studied community to gain access to data and a level of a comprehensive and holistic understanding of the environment, to enable abductivist epistemology - i.e. the need to be an “insider”.
- In order to deploy participatory action research practices in a neutral and inclusively helpful way, one needs to be as intellectually flexible, open-minded and unbiased as possible, hence the need to be “uninformed”.
- Being an “uninformed insider” is a dynamic relationship with the field, requiring role-play, careful interaction with stakeholders and constant re-evaluation and repositioning in order to maintain the inside-outside and informed-uninformed balance.

Starting from the bottom of the list, it is self-evident that researcher's positionality is tied in with very dynamic positions and processes and only constant reflexive (re)evaluation and (re)configuration can enable a researcher to keep within the boundaries they set and reap their benefits. As noted by Mikecz:

> *“positionality is not solely determined externally in the context of an insider/outsider dichotomy but is on a continuum that can be proactively influenced by the researcher”* (Mikecz, 2012, p. 482)

Of particular importance is the everyday work that a researcher needs to do to maintain this balance and it is in this context that the aforementioned ethical and practical challenges of uninformed insider approach come to the fore. Rhetoric and communication is the sole most important factor here, as well as setting up a clear framework of rules and behaviours, which is being constantly updated. Though the outsider-insider and informed-uninformed might at a first glance look like dichotomous relationships, they are, of course very spectral in nature. This makes the role-play and interaction more broadly very fluid, as in certain cases the uninformedness and insiderness need to be played up (or down) more than in others. The experience with the project outlined here was such that rhetorically crossing these two divisions was not too difficult or uncommon, but the overall the balance of my positioning in interactions was firmly on the side of being an insider and uninformed.

Moving to the trust-building and access, I found that being embedded in the field meant contacts with professional elite informants were not difficult to establish, but they had to be approached carefully. In particular, this relates to a personal introduction to (new) contacts and specifically noting affiliation status (with the University, research partners, project funders, etc.) and research type (i.e. academic). In my view, it is important to be honest and not omit or deny the entirety of the context/situation, but to frame its presentation to stress those credentials, associations and features of the research, which are assumed to be most trustworthy to a particular informant. As an example, studying a business community, early and proactive highlighting of care and concern for protecting sensitive information is critical. This often spills over in explanation of required information into a justification of research as a whole and more specifically the themes and questions in the interview. Here, like with the personal introduction, I argue that an honest but carefully framed approach works best and is the only ethically acceptable and practically available solution. In my case, this meant stressing the applied and developmental nature of my project, whilst being very clear there are also theoretical (academic) interests involved.

I found that it was a deeper relationship and investment I had in the community that enabled me to develop a holistic understanding of the field needed for abductivist knowledge-making process. It led to the identification of real-world issues and pains, and made possible continuous iterative dialogue with a multitude of actors (through formal data gathering and informal discussions) to develop theoretical understanding and applied solutions. Upon gaining access, I usually encountered no issues or challenges of being able to develop and maintain a longitudinal relationship with the studied community, though that does require work in itself (presence at industry events, supporting various stakeholders' projects, etc.). In addition, as the continuous physical presence (a desk at the research partners office, attendance and participation in events, visiting firms I interviewed instead of telephone or electronic communication) and virtual/social engagement (writing and publishing information, social media interactions, being "known") made me a true insider, so, when data collection was taking place, it became even more vital to assume, enact and internalise uninformedness.

As discussed previously, the uninformedness as part of this approach is conceptualised as both an acknowledgement of the true state of the knowledge asymmetry, as well as an epistemological necessity to remove as much bias and pre-conceptions as is possible. The latter is particularly important for two reasons, on one hand, to establish academic impartiality and associated integrity (an important condition of participatory action research), and on the other hand, to enable a holistic perspective on the field in order to successfully deploy abductivist research design. The considerations related to the role of uninformedness within the established epistemic regime are particularly interesting, as this is a deliberate act of researcher's positioning.

The activities behind the exposition and enactment of the uninformedness of the insider researcher are structured in two ways - the upfront positioning through a personal introduction and in the design and deployment of interview/data collection questions. In the positioning part, these are simple substantive moves of identification as a non-expert or acknowledgement of knowledge asymmetry in some other way. In the data collection part, however, the action of the researcher is more complex, within the suggested framework of “role-play”, which includes co-option and cooperation of the informant/interviewee. In the case of my project, the co-option and cooperation were obtained by an up-front explanation of the epistemic requirement for such procedure and behaviour, which was well-received by all informants/interviewees. In a similar way, my uninformedness was overall well-received in all informal interaction with the field and was harmonised well with my developed insider status.

Conclusion

All in all, I argue that the PERIpatetic Approach, based on participatory strategic ethnography of innovation and the “uninformed insider” position, provides an epistemologically optimal context for a social science researcher. As noted across this paper, this type of positionality for close-quarters research within professional elites has already de facto been established in many fields of social science, but here I argue that it is equally applicable to innovation (and business communities) of practice. This was illustrated with an example of researching the Space Sector in Scotland, outlining facets of research design, experience in the field, and reflexive analysis.

In addition, I argue that the adoption of such an approach leads to a greater scientific quality of our empirical work, through strengthening our reflexivity and allowing greater attention to nuances and details. This de facto development, which has been recognised in many settings and has been labelled by many researchers in different ways, needs more coherent and firmer systematic analysis in order to establish its scientific validity, hence the acute need for the type of analysis such as the one presented in this paper.

Hence, I would like to conclude with two observations (and possible limitations) and put forward some suggestions for the future development of similar reflexive accounts and analysis.

First and foremost, I have to highlight my appreciation for the degree of acceptance and support of my research ideas and eventually data collection by my research partners and gatekeepers, whose extraordinary readiness to assist me and engage with my work may not be universally applicable. Secondly, I have to note the crucial and outstanding intellectual openness and academic support within my department, which accepted and enabled this somewhat exotic mode of research. I believe it is possible that in this respect, I have been one of the lucky ones.

Finally, in terms of further reflexive engagement with this theme, I would like to encourage other descriptive and analytical accounts of research philosophy and its relationship to positionality, which are currently by and large still a rarity in the innovation literature. I hope that my honest and as complete as possible documentation of my experience in this respect attracts constructive feedback and (re)opens the discussion regarding the often falsely dichotomised and ignored issues of our presence in the arenas we study. I think of particular interest would be accounts of contention and rejection of researcher's position, which have so far been seen as “negative outcomes” and, hence, shared a similar fate to inconclusive or negative scientific findings. However, it is precisely these instances of inability to form these research relationships or their breakdowns, that might start to illuminate which of the many elements involved in constructing one’s research approach and position with respect to the studied environment are critical for successful trust-building and acceptance and which are (merely) individual preferences.

EPILOGUE

Conclusion

Thesis Summary

This portfolio attempts to examine the emergence of a new geographically-bound sectoral system of innovation from multi-level, strategically selected, perspectives. These perspectives were developed through the (newly framed) PERIpatetic Approach, in particular, deploying abductive epistemology. After the identification of suitable research aims – namely the mechanics of Open Innovation (transition) in SMEs (Part 1 of the thesis) and the role of innovation Intermediaries (Part 2 of the thesis) - a research strategy was designed to follow these up in a series of evolving steps. The empirical work itself represents a significant contribution to the knowledge, too, since my detailed analysis of the (New) Space Sector in Scotland is the first study of this sector in this region.

The first step (in Chapter 1) was to develop a detailed understanding of the emerging configuration of players in the studied landscape, specifically the interplay between policy (targets) and their on the ground realisation through specific interventions. Through hardware miniaturisation and increasing data access, the Space Industry has expanded significantly, in particular in the small-to-medium-sized enterprises (SME) domain, which in turn led to a change in the processes and systems of innovation and its emergence in new locales, for instance in Scotland. This was examined through secondary document analysis, in particular looking at policy documents and econometric reports, which were analytically contextualised using contemporary sources, participant observation and scoping interviews with key stakeholders. This research indicated the emerging need to understand the phenomenon of geographical clustering and its regional integration and to examine the ways in which innovation is delivered by interaction amongst the various stakeholder firms and other organisations. Hence, a broad data collection exercise was instigated, which looked at the selected episodes of changes within the studied sector towards more Open Innovation-driven interaction. Of particular interest became the living laboratory framing of innovation activity and the economic grouping of "Agile Space", which combined represents a significant departure from the traditional operations of the Space Sector SMEs (as explored in Chapter 2).

On top of political contextualisation, a very detailed organisational account of this transition towards a more networked approach to new product development was established (in

Chapter 3). In order to do so, a novel bridging concept of "innovation moments" was derived combining insights from flagship organisational learning, knowledge management and NPD process frameworks. Placing this sensitising concept at the heart of my empirical work enabled a (pre-)coded structural understanding to emerge from the qualitative interview data through filling in a data matrix with interviewees. In addition, the deployment of ego-centric Social Network Analysis (SNA) innovation network mapping, documented in detail the trends and directionality of the transition towards more Open Innovation models amongst the studied SMEs, noting the importance of both cognitive as well as geographical proximity for its spread.

A critical observation from the first half of the empirical research work was that innovation intermediaries play a significant role in enabling as well as connecting this sector. This was established through their central role in the composite whole innovation network (as constructed from the SMEs' ego-centred ones); the growing number of local public partners on the individual ego-centred networks; and by noting the importance of intermediation in both the living lab conceptualisation of innovation projects and through facilitating meetings enabling the formation of a regional-sectoral identity.

This reinforced the importance of the second "abduction" opportunity – the need to develop a comprehensive view of innovation intermediation activities. My efforts in this regard were additionally stimulated by the fact that the gatekeeping organisational unit in which I was embedded, was interested in my research precisely because they were setting up an innovation intermediary (Higgs Centre for Innovation); as well as me being selected for the Innovation Caucus 2017 internship to work on UK-wide policy advice on innovation intermediation.

I found it particularly striking that though knowledge/innovation brokerage literature was extensive and detailed, it lacked coherent systematisation, critically needed for a consistent operational and analytical application (Hannon, Skea and Rhodes, 2014; Venturini and Verbano, 2014). Hence, I have set out a comprehensive literature review and using dividing lines in the various strands of innovation intermediation literature, I derived an eight-part classification and accompanying typology of innovation intermediaries interventions (Chapter 4). Subsequently, deploying this theoretical structure on the empirical data I already collected from the Scottish Space Sector SMEs and additionally collected through a small survey of key innovation intermediaries' staff, I proposed four specific systemic roles various innovation intermediaries can fulfil within an innovation system, by enabling, equipping, shaping and moving the development of its constituent players (as presented in Chapter 5).

Zooming in into the example of the innovation intermediary being developed at my gatekeepers organisation, I further noticed that by comparison to other similar projects elsewhere, specific structural differences seem to be emerging. In particular, having won an Overseas Institutional Visit funding by SGSSS in 2018, I have spent three months working with colleagues in the Centre for the Study of Science in Slovenia, examining the budding Space Sector there. One innovation intermediation project was particularly dominant, the Centre of Excellence Space.Si. Comparing its set up to the development of the Higgs Centre for Innovation in Edinburgh pointed to the critical differences in the political context of the two centres' establishment, leading on to a very different interpretation of their mandate and interventions (as analysed in Chapter 6). Linking those findings to the wider picture of sectoral development both in Slovenia as well as Scotland led to my call for a more balanced approach between focusing on R&D and/or business development support interventions.

Finally, looking across the entirety of this thesis, two main analytical objectives for discussion have emerged – the need for a coherent merger of the various approaches in studying innovation within the context of a (innovation culture) transition, and the need to explicitly analyse the (philosophical) positioning of a researcher in such complex, multi-perspectival research. Both of these issues are also of much wider concern in the literature – tensions between innovation studies and science and technology studies approaches are frustrating enquiries (Martin, 2016; Williams and Velasco, 2016) and the changes in mode of research demand new and more fluid philosophical positions (Welch *et al.*, 2002; Schurz, 2018). Hence, these two issues were explored in turn.

Firstly, I developed a Multi-Level Perspective (MLP) on the Geographically-bound Sectoral Systems of Innovation (GSSI) (Chapter 7). I argued for explicitly linking the various approaches used and their integration in a strategic effort to bridge the divide between social science and management approaches to the study of innovation. Only by approaching the phenomenon of innovation in a comprehensive and coherent manner can the strengths of applications of our analysis and its theoretical rigours be properly established, without slipping either into normitivisation of policy and economics or developing overly localised and descriptive accounts. Furthermore, this specific attempt at bridging the innovation studies and science and technology studies approaches to systemic transitions in innovation has additional currency in engaging with both intellectual frameworks as equals and not calling for subjugation of either view in favour of the other.

Secondly, I developed a new perspective on the interplay between research design, data collection and theory building, which is summed up in what I termed the PERIpatetic Approach or Practical Epistemology for Researching Innovation (as outlined in Chapter 8). The framework of this approach brings together principles of multi-perspective ethnographic research design, embedded empirical work, responsive problem-driven conceptual development and extensive reflexive introspection. I have also framed the methodological set-up of "participatory strategic ethnography of innovation" and evolved further (my) researcher positionality, as an “uninformed insider”.

Theoretical Contributions

The overarching research aim of this thesis was to establish a coherent system-level understanding of the mechanics of inter-organisational practices and networks, which enable open innovation transition within high-tech SMEs, as well as what innovation intermediaries can do to support them. Whilst the initial drive for this study has come from the practitioners’ concerns regarding lack of comprehensiveness and clarity in meso-level/networked innovation process, my theory review and exploration quickly identified this to be a critical challenge within the literature as well. This led to the dominant agenda of my research to centre on theoretical integration.

The particular focus of integration were the competing innovation studies and science and technology studies approaches to researching innovation (Williams and Velasco, 2016), systemic versus processual theories of innovation (Green *et al.*, 1999) and a fragmented innovation intermediation literature (Hannon, Skea and Rhodes, 2014). Though there have been attempts to address some of these concerns in the past, they were often based on a “minimum value proposition” approach to integration. As such, the developed mergers were either additive, and as a result overly complex (as is the case with most innovation intermediation systematisations), or lacked genuine desire for new comprehensive solutions (as with several cases of IS-STS integration, where each tried to fit the other inside existing frameworks). In this thesis, theoretical integration was deployed as a direct response to these two past issues – my approach was focused on merger and reduction of concepts (rather than their addition) and adopting equal/symmetrical and impartial analysis of points of convergence.

The theoretical development within this thesis was done through an iterative process outlined in Figure 23, on the next page.

In particular, it centres on one grounding theoretical landscape - Open Innovation (greyed area). The conceptual development started from existing theories in innovation systems, multi-level perspective and innovation intermediation on the left, with concepts such as living laboratories and absorptive capacity (dashed-line box) showing promising bridging opportunity between the three. These concepts were integrated further (through "innovation moments") feeding into reframed Geographically-bound Sectoral Systems of Innovation (GSSI) development (in solid line box) and Multi-Level Perspective (MLP) framework. This was also supplemented by systemisation of innovation intermediation models, which both fed into the overall MLP-GSSI integration, as well as being a new theoretical framework in its own right.

In parallel, my philosophical/methodological position was evolved through merging strategic ethnography and participatory action research, and by forming "uninformed insider" positionality backed by critical realism and abductive epistemology. I structured these developments together into the PERIpatetic Approach (noted, by a dashed line, to have underpinned all conceptual development).

The conceptual development throughout this thesis is outlined in more detail in the next section.

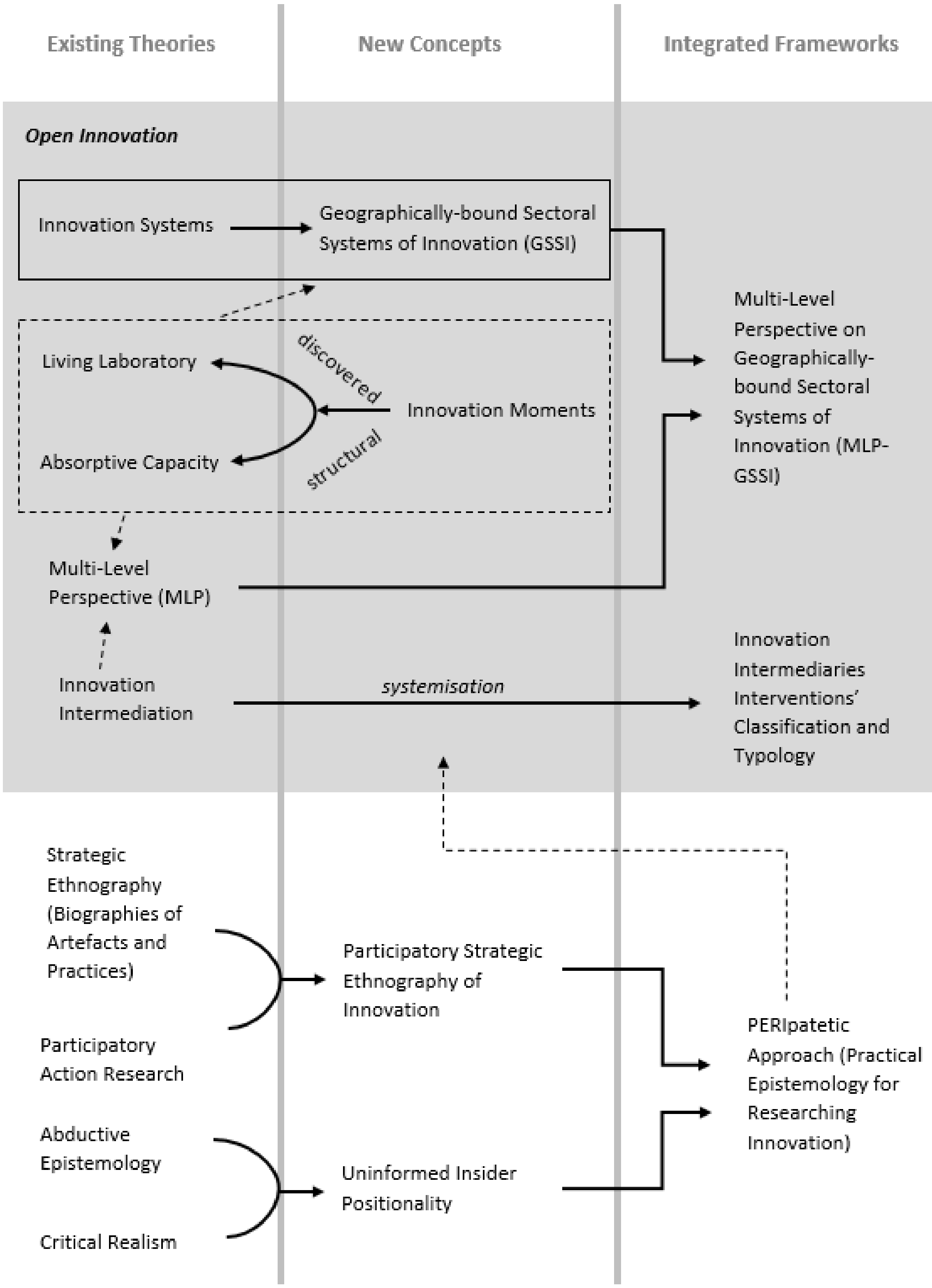


Figure 23 - Schematic outline of the theoretical development through this thesis, including iterative progress from existing theories through the deployment of novel concepts and towards the three new integrated frameworks.

Conceptual Development

Starting from the existing theories of (Sectoral) Systems of Innovation (SSI) and Multi-Level Perspective (MLP), these were probed empirically by defining and refining linking concepts. The most important ones were the inter-organisational interactions captured by Living Laboratories (Bergvall-Kåreborn *et al.*, 2009; Leminen, Westerlund and Nyström, 2012; ENLL - European Network of Living Labs, 2019) and the organisational learning through absorptive capacity (Cohen and Levinthal, 1990; Zahra and George, 2002; Sun and Anderson, 2010). These concepts were further refined by arguing that Living Lab(s) can also be "discovered" rather than "constructed" and for the absorptive capacity to apply in the case of structural organisational learning, not a merely substantive one.

Consequently, I have proposed as the critical contribution to knowledge the combined Multi-Level Perspective on Geographically-bound Sectoral Systems of Innovation (MLP-GSSI) model. This brought in alignment the three elements of SSI (institutions, actors/network and knowledge/technologies) with the three elements of the MLP (socio-technical regimes, actors and socio-technical systems) into institutions/socio-technical regimes, actors/networks and socio-technical systems of knowledge/technologies (STSKT), all three together making the socio-technical assemblages (STA). Merging this theoretical development with my analysis of the geographically and sectorally contextualised example of a move towards open innovation - the emergence of the (New) Space Sector in Scotland - , I further developed the multi-level perspective on the GSSI, by mapping these key elements. In particular, based on the empirical work in the first part of this thesis, these were identified as corresponding to macro-level (institutions/socio-technical regimes) of geo-sectoral innovation policy favouring Open Innovation, meso-level (actors/networks) the Scottish New Space's Living Laboratory, and micro-level (STSKT) organisational learning through structural absorptive capacity. The three elements are linked through understanding the innovation intermediaries' interventions (macro-meso) and the novel concept of innovation moments (meso-micro).

Specifically, the concept of "innovation moments" was introduced to bring discovered Living Lab and structural absorptive capacity together. This was based on the research framing of the "innovation project" as the "object" of study as per the Oslo Manual (OECD, 2007a) and the existing description of an innovation moment as a way to study innovation processes through phases of NPD, or technical or commercial challenges (Edwards, 2000; Edwards, Delbridge and Munday, 2005). The extended "innovation moment" conceptualisation explicitly brought together NPD process model phases (Bhuiyan, 2011), the theories of innovation processes on the "fuzzy front end" (Koen *et al.*, 2001), and the integrated absorptive capacity - organisational learning framework (Sun and Anderson, 2010). Importantly, this concept not only points to the linkages between the different levels/elements of the studied system, but it can be also deployed as "sensitising concept" (van den Hoonaard, 2008; Wegener, 2014) in empirical work.

Here, one additional contribution is the adopted research mechanism, in particular joining the Social Networks Analysis (SNA) (Scott, 1988), which was so far mainly limited to the study of organisational structure (Powell, 2005; Lee *et al.*, 2010) and in-depth qualitative investigation of innovation and NPD processes in SMEs using the sensitising concept of "innovation moment". Moreover, have proposed several other new technical tools, such as deploying a matrix for data collection, a new diagrammatic representation of ego-centric SNA analysis and a whole-network assembly.

On innovation intermediation, the theoretical development trajectory followed a more established systematic literature review-driven model design, leading to interventions' classification and typological model development, followed by empirical validation. In particular, using the dividing lines in the literature, a redefinition of innovation intermediary and re-focusing the attention to the intervention rather than structural role, I proposed a cross-referenced classification with eight distinct classes, split along two categories (with four sub-categories) and two qualifiers. These were linked to contextual enabling factors (close involvement, systemic investment, soft leadership, strong vision/mandate), and were developed empirically to link to roles of enabling the ecosystem, equipping the players, shaping a common vision and moving the development.

Finally, analysing the overarching philosophical position within the PERIpatetic approach, I made a series of theoretical developments. Starting from the component elements of strategic ethnography (Pollock and Williams, 2010) and participatory action research (McIntyre, 2007) I devised an ethnographic methodological position, which comprised the dynamic multi-perspective fluidity of this research as well as its embeddedness within the field. This was further supported my approach to researcher's positionality, by identifying myself not as an informed outsider (Welch *et al.*, 2002), but an uninformed insider, which is compatible with the in-the-field abductive epistemology and introspective critical realism.

Overall, this intellectual journey resulted in a series of conceptual development structured around the overarching interest in Open Innovation. In particular, the interrelated nature of the emerging theoretical frameworks points to their common roots in a paradigmatic shift in the "culture of innovation" towards Open Innovation. The intention behind this thesis is to structure these frameworks in a detailed and coherent manner so that the past few decades of divergent enquiries will not continue to hinder the core synergies at stake when these insights are applied.

Thus, I believe that the resulting theoretical framework and conceptual development is an original contribution to knowledge, which can be of significant interest to further studies. In particular, the integration of the Multi-Level Perspective (MLP) with the (Geographically-bound) Sectoral Systems of Innovation theory, can be used for analysing many system-level transitions and associated organisational behaviour changes. Understanding better the available innovation intermediation support mechanisms leads to better innovation policy analysis and application. Finally, practically developed and theoretically grounded PERIpatetic Approach can empower further enquiries in many social science disciplines.

Limitations and Further Research

Like any study, this portfolio is not without its limitations. The empirical work was somewhat constrained by the expected short timescales. Of particular use would be the ability to run focus groups with the studied companies' staff and a focus group with representatives from all studied innovation intermediaries. Repeating the same study in a few years' time could illuminate further the dynamic evolution of the studied regional-sectoral innovation system, as would access to more of companies' planning documents and meetings/discussions.

As part of the iterative theoretical and empirical development, several alternative avenues of enquiry were also tested in order to ensure this is the optimal way to explore my research aims, in particular, bibliometric study and impact evaluation. Preliminary analysis using the Scopus database showed a very low volume and poor quality of publications and patent data, which was supported by qualitative data obtained through scoping interviews and from the gatekeepers. I was informed that due to the highly competitive environment and inefficiency of formal intellectual property protection, the studied firms rely on trade secrets and exploitation via "first to market" competitive advantage. Similarly, the technological/engineering and scientific work within the research sphere was also not quantitatively strong enough for a robust statistical analysis. Hence, I had to discount bibliometric as a useful tool for this study. However, this might change in the future at which point these complementary tools should be explored again.

Secondly, another proposed avenue for research was examining the impact of innovation support mechanisms using quantitative (econometric) data, especially in the context of the newly established Higgs Centre for Innovation. However, with the delays in the setting-up of the Centre, as well as the results of a literature review pointing to a very weak correlation between econometric data and impact counterfactuals, I discounted this line of enquiry as well. Hence, I focused more on the conceptual understanding of the role of innovation intermediaries within the studied innovation system. However, a return to the impact evaluation aspects of innovation intermediation would be a fruitful avenue in the future.

Finally, as the key role of close-proximity networking and knowledge flow/transfer became apparent both within the theoretical framing (i.e. Open Innovation) as well as empirically, I put a stronger emphasis on detailed understanding of local phenomena, which shifted the overall focus of this work towards the exclusively Scottish players and hence moving away from the analysis of the UK Space Sector as a whole. However, questions about different geographical integration (or lack thereof) could also prove fruitful avenues for UK-wide or even Europe-wide studies.

In addition, though I refer to it as the "Scottish Space Sector" throughout this thesis, two omissions were made from the start, which I point out in several places. Namely, the perspective I established explicitly excludes both military space operations in Scotland, as well as multinational corporations. The reasons for these choices are predominantly to do with my focus examining the innovation system of SMEs (in which the Scottish branches of large corporations or military do not feature significantly, as found in innovation network analysis), as well as the completely different (nationally and internationally dispersed) operational and R&D model they adopt. Studies examining their role(s) in the Scottish (New) Space Sector might be called upon in the future, though, as with the development of spaceports, both military, as well as large corporations, are becoming more involved in the ecosystem.

Though I tried to be as reflexive as possible in both (meta-) analysing my data analysis as well as my participation in the field more broadly, it is also possible (or even likely) that some of the findings presented throughout this thesis express some degree of my personal preferences and biases. In fact, I do not believe that any research work can be truly free of such influence and so I leave it to any reader of this work to point out any favouritism they might find I have expressed in my presentation of the data. As a baseline, it is probably true to say that I have by and large found the emergence of the Scottish Space Industry a positive development and have sympathised with moves and positions to strengthen its core and expand its reach. Through conducting participatory action research I have also embed myself into a team with a particular interest in innovation intermediation and have taken on board their desire to see it succeed. However, I do not consider these positions as unethical, if anything the reverse. Firstly, I do not believe there is a "view from nowhere" and I find it more human to expose and embrace one's bias, than trying to eradicate it - I have sincere doubts the latter would ever work entirely! Secondly, I believe that my presence and providing the "challenge function" (Kattirtzi, 2016) within the organisation where policy and organisational decisions are taken is precisely the role social scientist should (be more eager to) adopt.

In all, I hope the papers presented in this thesis provide as complete and insightful picture of the Scottish Space Sector as possible and future research can expand on the various strands left insufficiently explored. To conclude, in the next section, I present some additional observations and comments about research on the Open Innovation transition and the New Space innovation culture.

Concluding Remarks and Observations

Overall, there are clear indications that the development of the innovation “culture” within the Scottish Space Industry features elements of frontier-leading industries such as much examined biotech and information technologies (IT). In many ways the Space Sector is a half-way house between the two, biotech’s high investment, protracted development, heavily reliant on basic research, and IT’s low investment, short development cycle, applied R&D. The transition examined in this thesis, characterised by the industry analyists as a move from multi-national corporations dominated 2nd generation, to the SME-led 3rd generation (“New Space”), seems to challenge the Space Sector by adopting more of the IT position. As presented in Chapter 3, this can be seen through organisational learning, taking ideas from related IT fields and then adopting them further across the value chain. This shift in innovation culture also has a very material, physical effect on these companies, with Silicon valley-inspired kitchens/bars, recreation tables and social areas installed in most of the “New

Space" firms (interestingly, this is true both in Scotland as well as in Slovenia), (re-)enforcing a particular version of entrepreneurial innovation and creativity (Van Meel and Vos, 2001).

Whilst examining a transition, it is also important to note what has not changed. The overall legal, regulatory and risk management frameworks (political and economic) have not evolved significantly. Though the UK has brought forward legislation to enable space launch opportunities, this has not yet born any operations, and implementation-level policy is still unfinished (Ross, 2019). The same applies to the critical spacecraft insurance regime. In addition, the big multinational corporations still dominate the traditional (state-funded) space sector markets. Hence, they do not feel threatened by New Space entrants and largely let their development proceed unimpeded. The UK government investment still favours military (telecommunications) domain (Skynet System); commercial money-makers (satellite TV, in particular, BskyB) are preoccupied with diversifying (in media, ground data infrastructure, etc.) to offset the drop in satellite dish installations; and international (EU) spending favours large scale critical infrastructure (satellite navigation – Galileo Programme; Earth Observation – Copernicus Programme). In contrast to traditional state procurement incentives, in many countries (including the UK) the recent emphasis on bottom-up SME-led innovation policy scouted out opportunities for potential market expansion.

However, markets must be economically viable to survive in the long run and a potentially bigger stumbling blocks are investors. Of particular interest within the studied group of SMEs are several "New Space" data application firms, who have adopted a very open-ended new product development processes, as they themselves make very clear. In one such company, they espouse as their raison d'etre that "every problem has a Space solution", which enables them to engage in a variety of projects related to their expertise in Earth Observation. However, such an approach is unlikely to yield a quick and clear economic return on investment. In the case of this firm, that is somewhat irrelevant, as the level of external capital investment (beyond that of the management team) is negligible. But in more venture-capital-backed start-up this could be a serious problem. In particular, in one of the other studied companies, the lead entrepreneur and CEO was publicly replaced by a more marketing and sales-minded management team, after his longer-term vision for slow development of the innovative capability and a wider product range within the company was rejected by angel investors in favour of clearer route-to-market and exit strategies. The interim CEO stunned the gathered Scottish space industry colleagues at a large conference by declaring: “the fact is that nobody here is making any money – and that cannot go on forever!”.

However, perhaps it can. In particular, it seems that different motivation drives leaders in this field. Many are far more committed to working with the space industry technology rather than optimising return on investment and get rich. Such attitude to lifestyle entrepreneurship (in particular by most academic spin-offs) leads to a different organisational structure and activities. These more easy-going innovation processes are routed in long-term relationships with research departments and knowledge transition on a deeper, more engaged level. In particular local autonomy and long-standing connections are seen as essential for successful development of such a stable symbiotic innovation system. That does not mean that no promising new markets are established with a significant degree of sophistication, for instance, as shown in Chapter 2 regarding the product re-alignment from climate change towards agri-food opportunities.

Since the “Living Lab” framing of these explorations inherently incorporates interdisciplinary connections and a closer innovator-regulator-user relationship, the ethics of these processes are a critical co-enabler of sustainable relationships. In the first instance, this relates in particular to the development of trust amongst all stakeholders and an appreciation of any existing or emerging power structures. In particular, we could examine more closely the final of the "triple helix" components - i.e. the science/academia - and its roles, approach and method of engagement in the innovation systems and processes described here. Furthermore, expanding the definition of stakeholders into a quadruple and examining (general) public(s) engagements with and views on these developments would be in my view equally beneficial. This is particularly true as an increasing number of technologies examined within the study of innovation in the space sector are now crossing into politically very contentious debates, be it automation of work/expertise through robotics and AI, or the need to balance the individual's freedoms with protecting our collective environment, or the access to and ownership of (big) data.

Specifically, the effort to disseminate the results of my research complemented my previous science communication and public engagement work, which was particularly beneficial to recognise the societal concerns and their geographical variations. Future research in space techno-culture could focus in particular on critical issues social impacts from Earth Observation data, especially with Sustainable Development (Goals) in mind. Though the application of such products and services may be presented in terms of "public good", the ownership and access to data, the transparency of data acquisition and analysis, and the unknown effects of automation and artificial intelligence may all lead to contentious debates and fruitful social scientific analysis.

Linking these issues with the evolving role of public scientific institutions as well as the changing political environment and economic development impetus are only a few angles that could be taken in future research. With astronomy and space technology so clearly exemplifying the intermediation between inaccessible and local, they feature strongly in various kinds of futurology, from "science fiction" to "serious" techno-scientific imaginaries[44]. The merger of systematic and systemic enquiry into these relationships and their futuristic counterfactuals could well inspire experimentation in nascent communities within the University of Edinburgh, for instance, the Edinburgh Futures Institute.

I believe these avenues of further research will prove fruitful and I hope that my work presented over these pages will aid future researchers in their pursuit.

[44] Using non-traditional "research" media, such as arts-led research, allows for a different kind of connection with the subject matter as well as with (non-academic) audiences. Such methods are opening further opportunities for developing applications stemming from my research as well, in particular through projects around "Futures Literacy" and "Utopia Laboratory" (https://efi.ed.ac.uk/blog-efi-utopia-lab-pilot/). Critically, these perspectives enabled me to extend the horizon of my future research towards the important ways in which innovation shapes the future through anticipatory and imaginary mechanisms, both as research tools for understanding the current development of the high-tech innovation landscape, as well as policymaking tools for "designing" its future.

References

1st Scottish Space Symposium - University of Strathclyde (2010). Glasgow. Available at: https://www.strath.ac.uk/advancedspaceconceptslaboratory/newsevents/scottishspacesymposia/1stscottishspacesymposium/ (Accessed: 24 December 2018).

Abbate, T., Coppolino, R. and Schiavone, F. (2013) 'Linking Entities in Knowledge Transfer: The Innovation Intermediaries', *Journal of the Knowledge Economy*, 4(3), pp. 233–243. doi: 10.1007/s13132-013-0156-5.

Abernathy, W. J. and Utterback, J. M. (1978) 'Patterns of Industrial Innovation', *Journal Title: Technology review. Ariel*, 64, pp. 228–254. Available at: http://teaching.up.edu/bus580/bps/Abernathy.

Acs, Z. and Audretsch, D. (1988) 'Innovation in Large and Small Firms: An Empirical Analysis', *The American Economic Review*, 78(4), pp. 678–690. Available at: http://www.jstor.org/stable/1811167 (Accessed: 21 April 2019).

Adams, P., Fontana, R. and Malerba, F. (2013) 'The magnitude of innovation by demand in a sectoral system: The role of industrial users in semiconductors', *Research Policy*, 42(1), pp. 1–14. doi: 10.1016/j.respol.2012.05.011.

Adams, W. and Adams, W. J. (1972) 'The military-industrial complex: A market structure analysis', *The American Economic Rewiew*, 62(1/2), pp. 279–287. Available at: https://www.jstor.org/stable/1821553?casa_token=VF5LHeTEs8AAAAAA:YV_RJYv1n_d31jWLHwt0gZC1yQAv1gGFdEAQeutFFiEkG3CxNSSG9tMIrFj-2BzPioZ4kiVannX7ZAzySZD8akGfIEiyqkP0Mh80mwmZXp7IStqa1i6OTg (Accessed: 30 March 2019).

Adlen, S. (2011) *Innovation in the Global Space Industry*. Imperial College London.

'Agile Space Group - Scotland: Home of Agile Space' (2017). Agile Space Group, p. 4.

Agnew, J. (2018) 'Too many Scotlands? Place, the SNP, and the future of nationalist mobilization', *Scottish Geographical Journal*. Routledge, 134(1–2), pp. 5–23. doi: 10.1080/14702541.2017.1413206.

Agogué, M. *et al.* (2017) 'Explicating the role of innovation intermediaries in the "unknown": a contingency approach', *Journal of Strategy and Management*, 10(1), pp. 19–39. doi: 10.1108/JSMA-01-2015-0005.

Agogué, M., Ystrom, A. and Le Masson, P. (2013) 'Rethinking the Role of Intermediaries As an Architect of Collective Exploration and Creation of Knowledge in Open Innovation', *International Journal of Innovation Management*, 17(02), p. 1350007. doi: 10.1142/S1363919613500072.

Almirall, E., Lee, M. and Wareham, J. (2012) 'Mapping living labs in the landscape of innovation methodologies', *Technology Innovation Management Review*, 2(9), pp. 12–18. doi: 10.22215/timreview/603.

Almirall, E. and Wareham, J. (2008) 'Living Labs and open innovation: roles and applicability', *The Electronic Journal for for Virtual Organizations and Networks*, 10(3), pp. 21–46. Available at: http://www.technology-management.de/projects/264/Issues/eJOV.

Alvarez, S. A. and Barney, J. B. (2010) 'Entrepreneurship and Epistemology: The Philosophical Underpinnings of the Study of Entrepreneurial Opportunities', *Academy of Management Annals*. Routledge, 4(1), pp. 557–583. doi: 10.5465/19416520.2010.495521.

An Interview with the European Space Agency (ESA's) Business Incubation Centre (BIC) UK (2018) *Astropreneurs*. Available at: http://astropreneurs.space/2019/02/07/an-interview-with-the-european-space-agency-esas-business-incubation-centre-bic-uk/ (Accessed: 1 April 2019).

Anderson, K. *et al.* (2017) 'Earth observation in service of the 2030 Agenda for Sustainable Development', *Geo-spatial Information Science*. Taylor & Francis, 20(2), pp. 77–96. doi: 10.1080/10095020.2017.1333230.

Antikaninen, M., Mäkipää, M. and Ahonen, M. (2009) 'Motivating and supporting collaboration in open innovation', *Technology Management*, 13(1), p. 24.

Aschbacher, J. and Milagro-Pérez, M. P. (2012) 'The European Earth monitoring (GMES) programme: Status and perspectives', *Remote Sensing of Environment*. Elsevier, 120, pp. 3–8. doi: 10.1016/j.rse.2011.08.028.

Asheim, B. T. (2013) 'Smart specialisation - Old wine in new bottles or new wine in old bottles?', *ERSA conference papers*. European Regional Science Association. Available at: https://ideas.repec.org/p/wiw/wiwrsa/ersa13p476.html (Accessed: 30 May 2019).

Asheim, B. T. (2019) 'Smart specialisation, innovation policy and regional innovation systems: what about new path development in less innovative regions?', *Innovation: The European Journal of Social Science Research*. Routledge, 32(1), pp. 8–25. doi: 10.1080/13511610.2018.1491001.

Asheim, B. T., Boschma, R. and Cooke, P. (2011) 'Constructing Regional advantage: Platform policies based on related variety and differentiated knowledge bases', *Regional Studies*, 45(7), pp. 893–904. doi: 10.1080/00343404.2010.543126.

Asheim, B. T., Grillitsch, M. and Trippl, M. (2017) 'Regional innovation systems: Past - present – future', in Shearmur, Richard Carrincazeaux, C. and Doloreux, D. (eds) *Handbook on the geographies of innovations.* Edward Elgar, pp. 45–62. Available at: https://books.google.co.uk/books?hl=en&lr=&id=pvJ-DQAAQBAJ&oi=fnd&pg=PA45&dq=lack+of+innovation+systems+integration&ots=i4sPMDjm6i&sig=gQhO39yYom3C_KcAdrgr2vbYolg (Accessed: 5 April 2019).

Asheim, B. T., Smith, H. L. and Oughton, C. (2011) 'Regional Innovation Systems: Theory, empirics and policy', *Regional Studies*, 45(7), pp. 875–891. doi: 10.1080/00343404.2011.596701.

Atkinson, P. and Hammersley, M. (1998) 'Ethnography and participant observation', in *Strategies of Qualitative Inquiry*. Thousand Oaks: Sage, pp. 248–261. Available at: http://www.academia.edu/download/8222015/6461181041799.pdf (Accessed: 2 April

2019).

Autio, E. (2014) *Innovation from big science: enhancing big science impact agenda*. London: Department of Business, Innovation and Skill. Available at: http://dera.ioe.ac.uk/19649/1/bis-14-618-innovation-from-big-science-enhancing-big-science-impact-agenda.pdf.

Autio, E., Hameri, A. P. and Vuola, O. (2004) 'A framework of industrial knowledge spillovers in big-science centers', *Research Policy*, 33(1), pp. 107–126. doi: 10.1016/S0048-7333(03)00105-7.

Autio, E., Kanninen, S. and Gustafsson, R. (2008) 'First- and second-order additionality and learning outcomes in collaborative RD programs', *Research Policy*. North-Holland, 37(1), pp. 59–76. doi: 10.1016/J.RESPOL.2007.07.012.

Axtell, C., Holman, D. and Wall, T. (2006) 'Promoting innovation: A change study', *Journal of Occupational and Organizational Psychology*. John Wiley & Sons, Ltd (10.1111), 79(3), pp. 509–516. doi: 10.1348/096317905X68240.

Banks, M. (2018) 'UK space sector set for take-off', *Physics World*. IOP Publishing, 31(7), pp. 13–13. doi: 10.1088/2058-7058/31/7/20.

Barca, F., Mccann, P. and Rodríguez-Pose, A. (2012) 'The case for regional development intervention: Place-based versus place-neutral approaches', *Journal of Regional Science*. John Wiley & Sons, Ltd (10.1111), 52(1), pp. 134–152. doi: 10.1111/j.1467-9787.2011.00756.x.

Barker, K., Sveinsdottir, T. and Cox, D. (2013) 'The "Innovation Turn" in Policy for Large Scientific Facilities: Reflections on introducing innovation support dimensions to the operation of scientific research infrastructure.', in *EU-SPRI*. Madrid, p. 37. Available at: https://www.escholar.manchester.ac.uk/uk-ac-man-scw (Accessed: 14th).

BBC News (2019) 'Western Isles in race to open UK's first spaceport', 11 June. Available at: https://www.bbc.co.uk/news/uk-scotland-highlands-islands-48593633 (Accessed: 4 July 2019).

Bellanova, R. and Duez, D. (2012) 'A Different View on the "Making" of European Security: The EU Passenger Name Record System as a Socio-Technical Assemblage', *European Foreign Affairs Review*. Kluwer Law International, 17(2/1), pp. 109–124. Available at: http://www.kluwerlawonline.com/abstract.php?area=Journals&id=EERR2012017 (Accessed: 27 April 2019).

Bendis, R. A., Seline, R. S. and Byler, E. J. (2008) 'A new direction for technology-based economic development: The role of innovation intermediaries', *Industry and Higher Education*, 22(2), pp. 73–80. doi: 10.5367/000000008784139460.

Bennett, R. (2008) 'SME Policy Support in Britain since the 1990s: What have We Learnt?', *Environment and Planning C: Government and Policy*. SAGE PublicationsSage UK: London, England, 26(2), pp. 375–397. doi: 10.1068/c07118.

Bergek, A. *et al.* (2008) 'Analyzing the functional dynamics of technological innovation systems: A scheme of analysis', *Research Policy*, 37(3), pp. 407–429. doi:

10.1016/j.respol.2007.12.003.

Berger, R. (2015) ‘Now I see it, now I don’t: researcher’s position and reflexivity in qualitative research’, *Qualitative Research*. SAGE PublicationsSage UK: London, England, 15(2), pp. 219–234. doi: 10.1177/1468794112468475.

Bergvall-Kåreborn, B. *et al.* (2009) ‘A Milieu for Innovation – Defining Living Labs’, in *2nd ISPIM Innovation Symposium, New York*, pp. 6–9.

Bessant, J. and Rush, H. (1995) ‘Building bridges for innovation: The role of consultancies in technology transfer’, *Research Policy*, 24(1), pp. 97–114.

Bhuiyan, N. (2011) ‘A Framework for successful new product development’, *Journal of Industrial Engineering and Management*, 4(4), pp. 746–770. doi: 10.3926/jiem.334.

Bille, M. and Lishock, E. (2004) *The first space race : launching the world’s first satellites*. Texas A & M University Press. Available at: https://books.google.co.uk/books?hl=en&lr=&id=_IHTWCQof2gC&oi=fnd&pg=PR9&dq=space+race+&ots=xNR2wSvM9m&sig=td67rnSCtP4sY3GiZRJP6tA5xTc#v=onepage&q=space race&f=false (Accessed: 30 March 2019).

Blaikie, N. (2004) ‘Abduction’, in Lewis-Beck, M. S., Bryman, A., and and Liao, T. F. (eds) *The SAGE encyclopedia of social science research methods*. London: Sage, pp. 1–2.

Blair, R. (2002) ‘Policy Tools Theory and Implementation Networks: Understanding State Enterprise Zone Partnerships’, *Journal of Public Administration Research and Theory*. Narnia, 12(2), pp. 161–190. doi: 10.1093/oxfordjournals.jpart.a003528.

Blomberg, J. and H Karasti, H. (2012) ‘Positioning ethnography within participatory design’, in *Routledge international handbook of participatory design*. Routledge , pp. 86–116. Available at: https://books.google.co.uk/books?hl=en&lr=&id=SnO5JDzp3t4C&oi=fnd&pg=PA86&dq=participatory+ethnography&ots=9EesNVirsw&sig=3SvDkYhUg78B-fkwSoGLstSxyDE (Accessed: 30 April 2019).

Bloor, D. (1991) *Knowledge and Social Imagery*. 2nd edn. Chicago: University of Chicago Press. Available at: https://books.google.co.uk/books?id=hnxy0DTMvkMC&dq=knowledge+and+social+imagery&lr=&source=gbs_navlinks_s (Accessed: 29 September 2019).

Blumer, H. (1954) ‘What is Wrong with Social Theory?’, *American Sociological Review*, 19(1), p. 3. doi: 10.2307/2088165.

Bodas Freitas, I. M. and von Tunzelmann, N. (2008) ‘Mapping public support for innovation: A comparison of policy alignment in the UK and France’, *Research Policy*. North-Holland, 37(9), pp. 1446–1464. doi: 10.1016/J.RESPOL.2008.05.005.

Bogers, M. and Lhuillery, S. (2011) ‘A Functional Perspective on Learning and Innovation: Investigating the Organization of Absorptive Capacity’, *Industry & Innovation*. Taylor & Francis Group , 18(6), pp. 581–610. doi: 10.1080/13662716.2011.591972.

Boon, W. P. *et al.* (2011) 'Demand articulation in emerging technologies: Intermediary user organisations as co-producers?', *Research Policy*, 40(2), pp. 242–252. Available at: http://www.sciencedirect.com/science/article/pii/S0048733310001964.

Boschma, R. (2013) *Constructing Regional Advantage and Smart Specialization: Comparison of Two European Policy Concepts*. 13.22. Utrecht. Available at: http://econ.geog.uu.nl/peeg/peeg.html (Accessed: 22 May 2019).

Boschma, R. and Frenken, K. (2011) 'Technological Relatedness, Related Variety and Economic Geography', in Cooke, P. et al. (eds) *Handbook of Regional Innovation and Growth.* London: Edward Elgar Publishing, pp. 187–197. doi: 10.1093/jeg/lbq053.

Boschma, R. and Frenken, K. (2012) 'Technological relatedness and regional branching', *Beyond Territory: Dynamic Geographies of Knowledge Creation, Diffusion, and Innovation*, pp. 64–81. doi: 10.4324/9780203814871.

Bowen, B. E. (2018) 'British strategy and outer space: A missing link?', *The British Journal of Politics and International Relations*. SAGE PublicationsSage UK: London, England, 20(2), pp. 323–340. doi: 10.1177/1369148118758238.

Bowen, G. A. (2009) 'Document Analysis as a Qualitative Research Method', *Qualitative Research Journal*. Emerald Group Publishing Limited, 9(2), pp. 27–40. doi: 10.3316/QRJ0902027.

Boyns, N., Spires, R. and Cox, M. (2009) *Evaluation of Smart: Scotland*. Available at: www.scotland.gov.uk/socialresearch. (Accessed: 9 May 2019).

Breschi, S. and Malerba, F. (1997) 'Sectoral innovation systems: technological regimes, Schumpeterian dynamics, and spatial boundaries', in Edquist, C. (ed.) *Systems of innovation: Technologies, institutions and organizations*. Abingdon: Routledge, pp. 130–156. Available at: https://www.researchgate.net/profile/Charles_Edquist/publication/228315614_Systems_of_Innovation_Technologies_Institutions_and_Organizations/links/5580106d08aec87640df220f/Systems-of-Innovation-Technologies-Institutions-and-Organizations.pdf#page=144 (Accessed: 27 April 2019).

Breschi, Stefano and Malerba, F. (2005) *Clusters, networks and innovation*. Edited by S Breschi and F. and Malerba. Oxford: Oxford University Press.

Brousselle, A. and Champagne, F. (2011) 'Program theory evaluation: Logic analysis', *Evaluation and Program Planning*, 34(1), pp. 69–78. doi: 10.1016/j.evalprogplan.2010.04.001.

Brown, J. S. and Duguid, P. (2001) 'Knowledge and Organization: A Social-Practice Perspective', *Organization Science*, 12(2), pp. 198–213. doi: 10.1287/orsc.12.2.198.10116.

Brüderl, J. and Preisendörfer, P. (1998) 'Network Support and the Success of Newly Founded Businesses', *Small Business Economics*, 10(3), pp. 213–225. doi: 10.1023/A:1007997102930.

Bryce Space and Technology (2016) 'The Annual Compendium of Commercial Space Transportation: 2016', in, p. 177. Available at:

https://www.faa.gov/about/office_org/headquarters_offices/ast/media/2016_Compendium.pdf.

Bryman, A. (2016) *Social Research Methods*. 5th edn. Oxford: Oxford University Press.

Bucar, M. (2015) *Stairway to Excellence Country Report: Slovenia*. doi: 10.2791/121910.

Bučar, M. and Rissola, G. (2018) *Place-Based Innovation Ecosystems: Ljubljana Start-up Ecosystem and the Technology Park Ljubljana (Slovenia)*. Brussels. doi: 10.2760/717413.

Bulkeley, H., Castán Broto, V. and Edwards, G. A. S. (2015) *An urban politics of climate change : experimentation and the governing of socio-technical transitions*. London: Book Now. Available at: https://books.google.co.uk/books?hl=en&lr=&id=TofZBAAAQBAJ&oi=fnd&pg=PP1&dq=socio+technical+assemblage&ots=Y-yfmEWgT7&sig=yHdf3giebT2loAjMyXrIQlgBdsg#v=onepage&q=socio technical assemblage&f=false (Accessed: 27 April 2019).

van Burg, E., Giannopapa, C. and Reymen, I. M. M. J. (2017) 'Open innovation in the European space sector: Existing practices, constraints and opportunities', *Acta Astronautica*. Pergamon, 141, pp. 17–21. doi: 10.1016/J.ACTAASTRO.2017.09.019.

Business Insider (2018) 'Why Space plc is now the Scottish frontier', December. Available at: https://www.insider.co.uk/special-reports/space-satellites-industry-scotland-gsi-13762109 (Accessed: 30 March 2019).

Bušljeta, N. (2019) *Space Technology*, *Slovenia.Si*. Available at: http://www.slovenia.si/visit/features/space-technology/ (Accessed: 31 May 2019).

Caleb, H. (2016) 'OneWeb gets $1.2 billion in SoftBank-led investment', *Space News*. Available at: https://spacenews.com/oneweb-gets-1-2-billion-in-softbank-led-investment/ (Accessed: 11 August 2018).

Callon, M. (1984) 'Some Elements of a Sociology of Translation: Domestication of the Scallops and the Fishermen of St Brieuc Bay', *The Sociological Review*. Wiley/Blackwell (10.1111), 32(1_suppl), pp. 196–233. doi: 10.1111/j.1467-954X.1984.tb00113.x.

Callum Norrie (2018) *Some Changes*, *Space Network Scotland Blog*. Available at: https://www.space-network.scot/blog/some-changes-at-space-network-scotland.html (Accessed: 24 June 2019).

Camagni, R. and Capello, R. (2013) 'Regional Innovation Patterns and the EU Regional Policy Reform: Toward Smart Innovation Policies', *Growth and Change*. John Wiley & Sons, Ltd (10.1111), 44(2), pp. 355–389. doi: 10.1111/grow.12012.

Capello, R. and Kroll, H. (2016) 'From theory to practice in smart specialization strategy: emerging limits and possible future trajectories', *European Planning Studies*. Routledge, 24(8), pp. 1393–1406. doi: 10.1080/09654313.2016.1156058.

Carlile, P. R. (2002) 'A Pragmatic View of Knowledge and Boundaries: Boundary Objects in New Product Development', *Organization Science*, 13(4), pp. 442–455. doi:

10.1287/orsc.13.4.442.2953.

Castellaci, F. *et al.* (2005) 'Advances and Challenges in Innovation Studies', *Journal of Economic Issues*, 39(1), pp. 91–121. doi: 10.1080/00213624.2005.11506782.

CEN (2013) *Technical specification CEN/TS 16555-1: Innovation Management - Part 1: Innovation Management System*. Brussels: CEN.

Chaminade, C. and Esquist, C. (2006) *Rationales for Public Policy Intervention in the Innovation Process: Systems of Innovation Approach*, *The Theory and Practice of Innovation Policy*. CIRCLE, Lund University. doi: 10.4337/9781849804424.00012.

Chapman, S. and Meliciani, V. (2018) 'Explaining regional disparities in Central and Eastern Europe', *Economics of Transition*. John Wiley & Sons, Ltd (10.1111), 26(3), pp. 469–494. doi: 10.1111/ecot.12154.

Chesbrough, H. (2003) *Open innovation : the new imperative for creating and profiting from technology*. Harvard Business School Press. Available at: https://books.google.co.uk/books?hl=en&lr=&id=OeLIH89YiMcC&oi=fnd&pg=PR17&dq=chesbrough+2006+open+innovation&ots=RE4DeOCKke&sig=GonbzZzQUiO10EHEMB5gadoYGS0#v=onepage&q=chesbrough.

Chesbrough, H. (2006) 'Innovation Intermediaries Enabling Open innovation', in *Open Business Models: How to Thrive in the New Innovation Landscape*, p. 33. doi: 10.1107/S1600536808017583.

Chesbrough, H. (2011) *Everything You Need to Know About Open Innovation*, *Forbes.com*. Available at: http://www.forbes.com/sites/henrychesbrough/2011/03/21/everything-you-need-to-know-about-open-innovation/.

Chesbrough, H. and Bogers, M. (2014) *Explicating Open Innovation: Clarifying an Emerging Paradigm for Understanding Innovation*, *New Frontiers in Open Innovation*. Oxford: Oxford University Press. doi: 10.1093/acprof.

Chesbrough, H. and Vanhaverbeke, W. (2011) *Open Innovation and Public Policy in Europe*, *Research Report*. doi: 10.2873/886211.

Chidamber, S. and Kon, H. (1994) 'A Research Retrospective of Innovation Inception and Success: The Technology-Push Demand-Pull Question', *International Journal of Technology Management*, 53(9), pp. 1689–1699. doi: 10.1017/CBO9781107415324.004.

Christensen, J. F., Olesen, M. H. and Kjær, J. S. (2005) 'The industrial dynamics of Open Innovation—Evidence from the transformation of consumer electronics', *Research Policy*. North-Holland, 34(10), pp. 1533–1549. doi: 10.1016/J.RESPOL.2005.07.002.

Clark, H. and Taplin, D. (2012) *Theory of Change Basics: A Primer on Theory of Change*, *ActKnowledge*. New York: Actknowledge. doi: 10.5327/Z201600010002RBM.

Clark, J. *et al.* (2013) 'Assessing the full effects of public investment in space', *Space Policy*, 30(3), pp. 1–14. doi: 10.1016/j.spacepol.2014.03.001.

Clyde Space (2017) ‘Clyde Space Wins Second Innovation Award in a Month’. Available at: https://www.clyde.space/latest/108-clyde-space-wins-second-innovation-award-in-a-month (Accessed: 29 July 2018).

Cohen, L. R. and Noll, R. G. (1986) ‘Government R&D Programs for Commercializing Space’, *The American Economic Review*, 76(2), pp. 269–273. Available at: https://www.jstor.org/stable/1818778?seq=1#metadata_info_tab_contents (Accessed: 30 March 2019).

Cohen, W. M. and Levinthal, D. A. (1989) ‘Innovation and Learning: The Two Faces of R & D’, *The Economic Journal*, 99(397), pp. 569–596. doi: 10.2307/2233763.

Cohen, W. M. and Levinthal, D. A. (1990) ‘Absorptive Capacity: A New Perspective on Learning and Innovation’, *Administrative Science Quarterly*. Sage Publications, Inc.Johnson Graduate School of Management, Cornell University, 35(1), p. 128. doi: 10.2307/2393553.

Colombo, M. G. *et al.* (2011) ‘Organizing Inter- and Intra-Firm Networks: What is the Impact on Innovation Performance?’, *Industry & Innovation*. Taylor & Francis Group , 18(6), pp. 531–538. doi: 10.1080/13662716.2011.601958.

Colombo, M. G., Dell’Era, C. and Frattini, F. (2015) ‘Contribution of innovation intermediaries to NPD process’, *R&D Management*, 45, pp. 126–146.

Comstock, D. A. and Lockney, D. (2007) ‘NASA’s legacy of technology transfer and prospects for future benefits’, in *A Collection of Technical Papers - AIAA Space 2007 Conference*, pp. 2969–2978. doi: doi:10.2514/6.2007-6283.

Cook, S. D. N. and Brown, J. S. (1999) ‘Bridging Epistemologies: The Generative Dance Between Organizational Knowledge and Organizational Knowing’, *Organization Science*, pp. 381–400. doi: 10.1287/orsc.10.4.381.

Cooke, P. (2001) ‘Regional Innovation Systems, Clusters, and the Knowledge Economy’, *Industrial and Corporate Change*, 10(4), pp. 945–974. doi: 10.1093/icc/10.4.945.

Cooke, P. (2002a) ‘Biotechnology clusters as regional, sectoral innovation systems’, *International Regional Science Review*, 25(1), pp. 8–37. doi: 10.1177/016001760202500102.

Cooke, P. (2002b) ‘Regional innovation systems: General findings and some new evidence from biotechnology clusters’, *Journal of Technology Transfer*, 27(1), pp. 133–145. doi: 10.1023/A:1013160923450.

Cooke, P. (2012) ‘Knowledge Economy Spillovers, Proximity, and Specialization’, in *Interactive Learning for Innovation*. London: Palgrave Macmillan UK, pp. 100–111. doi: 10.1057/9780230362420_5.

Cooke, P., Gomez Uranga, M. and Etxebarria, G. (1997) ‘Regional innovation systems: Institutional and organisational dimensions’, *Research Policy*, 26(4–5), pp. 475–491. doi: 10.1016/S0048-7333(97)00025-5.

Coombs, R. *et al.* (eds) (2001) *Technology and the market : demand, users and innovation*. Edward Elgar. Available at:

https://books.google.co.uk/books?hl=en&lr=&id=0Jb0__H1C1oC&oi=fnd&pg=PR7&dq=%22Coombs,+R.,+Green,+K.,+Richards,+A,+Walsh,+V.+(Eds.),+2001.+Technology+and+the+Market:+Demand,+and+Innovation.+Edward+Elgar,+Cheltenham,+UK.%22&ots=NiMAE90pyU&sig=FeuarMzgHIv3V (Accessed: 24 April 2019).

Cooper, R. G. (1990) 'Stage-gate systems: A new tool for managing new products', *Business Horizons*. Elsevier, 33(3), pp. 44–54. doi: 10.1016/0007-6813(90)90040-I.

Copestake, J. (2014) 'Credible impact evaluation in complex contexts: Confirmatory and exploratory approaches', *Evaluation*, 20(4), pp. 412–427. doi: 10.1177/1356389014550559.

Cornell, A. (2011) 'Five key turning points in the American space industry in the past 20 years: Structure, innovation, and globalization shifts in the space sector', *Acta Astronautica*, 69(11–12), pp. 1123–1131. doi: 10.1016/j.actaastro.2011.05.033.

Crabtree, A. (1998) 'Ethnography in participatory design', in *Proceedings of the 1998 Participatory design*. Stanford, CA, pp. 93–105. Available at: http://www.cs.nott.ac.uk/~pszaxc/work/PDC98.pdf (Accessed: 30 April 2019).

Crossan, M. M., Lane, H. W. and White, R. E. (1999) 'An Organizational Learning Framework: From Intuition to Institution', *The Academy of Management Review*, 24(3), p. 522. doi: 10.2307/259140.

Crossley, N. *et al.* (2015) *Social network analysis for ego-nets*. Sage.

Culver, L. *et al.* (2007) *Policies, Incentives, and Growth in the NewSpace Industry Executive Summary*. Available at: http://gwen.barnesos.net/NasaColab/Ken Davidian NGEC Supporting Docs/NewSpace Policies, Incentives and Growth_public version_4 Jan 2008.pdf (Accessed: 29 March 2019).

Dahlander, L. and Gann, D. M. (2010) 'How open is innovation?', *Research Policy*, 39(6), pp. 699–709. doi: 10.1016/j.respol.2010.01.013.

Dalziel, M. (2010) 'Why do innovation intermediaries exist?', in *Druid 2010: Opening Up Innovation: Strategy, Organization and Technology*. London: Imperial College London Business School, p. 23. Available at: http://www2.druid.dk/conferences/viewpaper.php.

Darrouzet, C., Wild, H. and Wilkinson, S. (2009) 'Participatory ethnography at work', in *Ethnography and the Corporate Encounter: Reflections on Research in and of Corporations*. New York: Berghahn Books, pp. 61–94. Available at: https://books.google.co.uk/books?hl=en&lr=&id=plrpIVCWizwC&oi=fnd&pg=PA61&dq=participatory+ethnography&ots=yI4MIkjLhF&sig=ep7tNdoH07siJqijgMLZVBdF5n0 (Accessed: 30 April 2019).

Daugėlienė, R. and Brundza, A. (2009) 'Theoretical Possibilities of Expression of Innovation in Tourism Sector: the Case of Scotland and Slovenia', *European Integration Studies*, (3), pp. 176–183. Available at: https://web.b.ebscohost.com/abstract?direct=true&profile=ehost&scope=site&authtype=crawler&jrnl=18228402&asa=Y&AN=43973313&h=6kJYMXPE64aejqAKAY64utixU53NLg3lKxxSfJxxcDwN03POjlzCQ%2FmUa9HIjMPJyJSeC6iRi7Rk5%2FLML%2FhyeA%3D%3D&crl=c&resultNs=AdminWebAuth&res (Accessed: 30 May 2019).

Davenport, S. (2005) 'Exploring the role of proximity in SME knowledge-acquisition', *Research Policy*. North-Holland, 34(5), pp. 683–701. doi: 10.1016/J.RESPOL.2005.03.006.

David, P., Foray, D. and Hall, B. (2013) 'Measuring Smart Specialisation: The concept and the need for indicators', pp. 1–7. Available at: http://cemi.epfl.ch/files/content/sites/cemi/files/users/178044/public/Measuring.

Déjean, F., Gond, J. P. and Leca, B. (2004) 'Measuring the unmeasured: An institutional entrepreneur strategy in an emerging industry', *Human Relations*. Sage PublicationsSage CA: Thousand Oaks, CA, 57(6), pp. 741–764. doi: 10.1177/0018726704044954.

Delamont, S. (2013) 'SAGE Qualitative Research Methods Collecting Data from Elites and Ultra Elites : Telephone and Face-to-Face Interviews with Macroeconomists', *Qualitative Research*, 7(2), pp. 203–216.

Dell'Era, C. and Landoni, P. (2014) 'Living Lab: A Methodology between User-Centred Design and Participatory Design', *Creativity and Innovation Management*. John Wiley & Sons, Ltd (10.1111), 23(2), pp. 137–154. doi: 10.1111/caim.12061.

Denis, G. *et al.* (2017) 'Towards disruptions in Earth observation? New Earth Observation systems and markets evolution: Possible scenarios and impacts', *Acta Astronautica*. Pergamon, 137, pp. 415–433. doi: 10.1016/J.ACTAASTRO.2017.04.034.

Deschamps, I., Macedo, M. G. and Eve-Levesque, C. (2013) 'University-SME Collaboration and Open Innovation: Intellectual-Property Management Tools and the Roles of Intermediaries', *Technology Innovation Management Review*, 3(3), pp. 33–41. Available at: http://timreview.ca/article/668.

Devezas, T. (2016) 'A Transforming Scenario: The New Space Agenda', *Journal of Aerospace Technology and Management*. Departamento de Ciência e Tecnologia Aeroespacial, 8(1), pp. 5–6. doi: 10.5028/jatm.v8i1.549.

DG Research Expert Group on 'Constructing Regional Advantage' (2006) *Constructing Regional Advantage: Principles - Perspectives - Policies*. Brussels. Available at: http://europa.eu.int/comm/research/rtdinfo/index_en.html (Accessed: 25 May 2019).

Dickson, P. (2001) *Sputnik : the shock of the century*. Walker Pub. Available at: https://books.google.co.uk/books?hl=en&lr=&id=ADqgAwAAQBAJ&oi=fnd&pg=PA1&dq=sputnik+beeps&ots=-sIK3aUoRQ&sig=b8BNoYW8oJZN8Teayq67CrrHB3Y#v=onepage&q=sputnik beeps&f=false (Accessed: 29 March 2019).

Doh, S. and Kim, B. (2014) 'Government support for SME innovations in the regional industries: The case of government financial support program in South Korea', *Research Policy*. North-Holland, 43(9), pp. 1557–1569. doi: 10.1016/J.RESPOL.2014.05.001.

Dorsey, K. (2017) 'Clyde Space strikes merger deal with AAC Microtec. Business Insider'. Available at: https://www.insider.co.uk/news/clyde-space-merger-aac-microtec-11737333.

Dosi, G. *et al.* (2006) 'Information, appropriability, and the generation of innovative knowledge four decades after Arrow and Nelson: An introduction', *Industrial and Corporate*

Change, 15(6), pp. 891–901. doi: 10.1093/icc/dtl028.

Dosi, G. and Winter, S. G. (2000) *Interpreting Economic Change: Evolution, Structures and Games*. 2000/08. Pisa. Available at: https://s3.amazonaws.com/academia.edu.documents/44382162/2000-08.pdf?AWSAccessKeyId=AKIAIWOWYYGZ2Y53UL3A&Expires=1555835208&Signature=wSn6F%2BEy2z3msn9akdykWH9lVGk%3D&response-content-disposition=inline%3B filename%3DInterpreting_economic_change_evoluti (Accessed: 21 April 2019).

Duff, A. (1996) 'Best Practice in Business incubator Management'. Available at: http://www.eifn.ipacv.ro/include/documentations_files/bestpracrpt.pdf (Accessed: 30th).

Ecometrica (2017) *Ecometrica secures breakthrough £14.2m UK Space Agency contract*. Available at: https://ecometrica.com/article/ecometrica-secures-breakthrough-14-2m-uk-space-agency-contract (Accessed: 11 May 2019).

Edler, P. *et al.* (2013) *Impacts of Innovation Policy: Synthesis and Conclusions*. Available at: http://research.mbs.ac.uk/innovation/ (Accessed: 15 January 2019).

Edquist, C. (2001) 'The Systems of Innovation Approach and Innovation Policy: An Account of the State of the Art', in *DRUID 2001*. Aalborg, p. 24. Available at: https://www.researchgate.net/profile/Charles_Edquist/publication/228823918_The_Systems_of_Innovation_Approach_and_Innovation_Policy_An_Account_of_the_State_of_the_Art/links/548177b90cf20f081e727cb6.pdf (Accessed: 28 April 2019).

Edquist, C. (2004) 'Reflections on the systems of innovation approach.', *Science & Public Policy (SPP)*, 31(6), pp. 485–489. Available at: https://login.e.bibl.liu.se/login?url=https://search.ebscohost.com/login.aspx?direct=true&db=aph&AN=16289145&site=eds-live&scope=site.

Edquist, C. and Johnson, B. H. (1997) 'Institutions and Organizations in Systems of Innovation', in Edquist, C. (ed.) *Systems of Innovation: Technologies, Institutions and Organizations*. London: Pinter, pp. 41–63. Available at: https://www.researchgate.net/publication/246482165 (Accessed: 28 May 2019).

Edwards-Schachter, M. E., Matti, C. E. and Alcántara, E. (2012) 'Fostering Quality of Life through Social Innovation: A Living Lab Methodology Study Case', *Review of Policy Research*. John Wiley & Sons, Ltd (10.1111), 29(6), pp. 672–692. doi: 10.1111/j.1541-1338.2012.00588.x.

Edwards, T. (2000) 'Innovation and organizational change: Developments towards an interactive process perspective', *Technology Analysis and Strategic Management*, 12(4), pp. 445–464. doi: 10.1080/713698496.

Edwards, T., Delbridge, R. and Munday, M. (2005) 'Understanding innovation in small and medium-sized enterprises: A process manifest', *Technovation*, 25(10), pp. 1119–1127. doi: 10.1016/j.technovation.2004.04.005.

Egbunike, O. (2016) *State of the innovation*, *Newable News*. Available at: https://www.newable.co.uk/news-and-views/840433299/state-of-the-innovation.-by-obi-egbunike-innovation-advisor-newable.php (Accessed: 15 January 2019).

Eisenhardt, K. M. (1989) 'Building Theories from Case Study Research', *Academy of Management Review*. Academy of Management Briarcliff Manor, NY 10510, 14(4), pp. 532–550. doi: 10.5465/amr.1989.4308385.

Elbert, B. R. (2004) *The satellite communication applications handbook*. Artech House. Available at: https://books.google.co.uk/books?hl=en&lr=&id=D9k5s2-mMKgC&oi=fnd&pg=PR15&dq=satellite+consumer+communications&ots=z7ueot_8iJ&sig=oGRkRrtop0uHwKE3TJY5nEq5yLI#v=onepage&q=satellite consumer communications&f=false (Accessed: 29 March 2019).

Elefteriu, G. (2018) *Britain's industry-led space policy "model" has been a resounding success. But can it survive the fierce competition of the new space race?*, *Policy Exchange*. Available at: https://policyexchange.org.uk/britains-industry-led-space-policy-model-has-been-a-resounding-success-but-can-it-survive-the-fierce-competition-of-the-new-space-race/ (Accessed: 2 April 2019).

Engel, J. S. (2015) 'Global Clusters of Innovation: Lessons from Silicon Valley', *California Management Review*. SAGE PublicationsSage CA: Los Angeles, CA, 57(2), pp. 36–65. doi: 10.1525/cmr.2015.57.2.36.

ENLL - European Network of Living Labs (2019) *What are Living Labs?* Available at: https://enoll.org/about-us/what-are-living-labs/ (Accessed: 22 March 2019).

Eriksson, M. *et al.* (2006) 'Living Labs as a Multi-Contextual R & D Methodology', in *The 12th International Conference on Concurrent Enterprising: Innovative Products and Services through Collaborative Networks, ICE 2006*, pp. 26–28. doi: 10.1109/ICE.2006.7477082.

ESA (2013) *Edinburgh readies for major scientific forum*. Available at: http://www.esa.int/Our_Activities/Observing_the_Earth/Edinburgh_readies_for_major_scientific_forum (Accessed: 11 August 2018).

ESA (2015) *European Space Agency Budget 2015*. Available at: http://www.esa.int/For_Media/Highlights/ESA_budget_2015.

ESA (2019a) *Copernicus Masters*. Available at: https://www.copernicus-masters.com/ (Accessed: 10 May 2019).

ESA (2019b) *UKube-1 (United Kingdom Universal Bus Experiment 1)*, *eoPortal Directory*. Available at: https://earth.esa.int/web/eoportal/satellite-missions/u/ukube-1 (Accessed: 10 May 2019).

Esionwu, C. A. (2014) *CubeSat Market Analysis and Cost Breakdown*.

Estalella, A. and Sánchez-Criado, T. (2015) *Experimental collaborations. Ethnography through fieldwork devices*, *Experimental Collaborations*.

European Commission (2014) *Regional Research and Innovation Strategies for Smart Specialisation (RIS3)*. Brussels. Available at: https://ec.europa.eu/regional_policy/sources/docgener/informat/2014/smart_specialisation_en.pdf (Accessed: 22 May 2019).

European Structural Funds: A smart, sustainable and inclusive Scotland in Europe (2015). Edinburgh. Available at: https://www.gov.scot/publications/european-structural-funds-smart-sustainable-inclusive-scotland-europe/pages/9/.

Faber, A. and Hoppe, T. (2013) 'Co-constructing a sustainable built environment in the Netherlands—Dynamics and opportunities in an environmental sectoral innovation system', *Energy Policy*. Elsevier, 52, pp. 628–638. doi: 10.1016/J.ENPOL.2012.10.022.

Faems, D. (2008) 'Open Innovation: Researching a New Paradigm - By H. Chesbrough, W. Vanhaverbeke and J. West', in *Creativity and Innovation Management*, pp. 334–335. doi: 10.1111/j.1467-8691.2008.00502.x.

Farole, T., Rodríguez-Pose, A. and Storper, M. (2010) 'Human geography and the institutions that underlie economic growth', *Progress in Human Geography*, 35(1), pp. 58–80. doi: 10.1177/0309132510372005.

Ferrary, M. and Granovetter, M. (2009) 'The role of venture capital firms in Silicon Valley's complex innovation network', *Economy and Society*, 38(2), pp. 326–359. doi: 10.1080/03085140902786827.

Feurstein, K. *et al.* (2008) 'Living Labs: a new development strategy. European Living Labs-a new approach for human centric regional innovation', pp. 1–14.

Flanagan, K. and Uyarra, E. (2016) 'Four dangers in innovation policy studies – and how to avoid them', *Industry and Innovation*. Routledge, 23(2), pp. 177–188. doi: 10.1080/13662716.2016.1146126.

Flanagan, K., Uyarra, E. and Laranja, M. (2011) 'Reconceptualising the "policy mix" for innovation', *Research Policy*, 40(5), pp. 702–713. doi: 10.1016/j.respol.2011.02.005.

Fleck, J. (1993) 'Innofusion: Feedback in the Innovation Process', in *Systems Science*. Boston, MA: Springer, pp. 169–174. doi: 10.1007/978-1-4615-2862-3_30.

Fleming, L., King, C. and Juda, A. I. (2007) 'Small Worlds and Regional Innovation', *Organization Science*, 18(6), pp. 938–954. doi: 10.1287/orsc.1070.0289.

Følstad, A. (2008) 'Living labs for innovation and development of information and communication technology: A literature review', *The electronic journal of virtual organizations and networks (eJov)*. Virtual Organization Network, 10(August), pp. 99–131. Available at: https://brage.bibsys.no/xmlui/handle/11250/2440026.

Foray, D. and Goenaga, X. (2013) *The goals of smart specialisation*. Brussells. Available at: https://publications.europa.eu/en/publication-detail/-/publication/225c8ada-7295-46b7-8711-714cca360b04/language-en (Accessed: 15 January 2019).

Foss, N. J., Lyles, M. A. and Volberda, H. W. (2009) 'Absorbing the Concept of Absorptive Capacity: How to Realize Its Potential in the Organization Field', *Ssrn*, 21(4), pp. 931–951. doi: 10.2139/ssrn.1513184.

Freeman, C. (1991) 'Networks of innovators: A synthesis of research issues', *Research Policy*, 20(5), pp. 499–514. doi: 10.1016/0048-7333(91)90072-X.

Freeman, C. (2003) *A Schumpeterian Renaissance?* 102. Available at: http://www.sussex.ac.uk/spru/ (Accessed: 28 March 2019).

Frenz, M. and Oughton, C. (2005) *Innovation in the UK regions and devolved administrations: A review of the literature*, *Final report for the Department of Trade and …*. London: Department for Trade and Industry. Available at: http://www.dti.gov.uk/iese/DTI_regional_innovation_review2.doc.

Frost and Sullivan (2018) *UK Spaceport Business Case Evaluation*. London. Available at: www.frost.com (Accessed: 28 March 2019).

Fuchs, E. (2009) 'The role of DARPA in seeding and encourage new technology trajectories', *Sloan Industry Studies Working Papers*, pp. 2001–2009.

Geels, F. W. (2002) 'Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study', *Research Policy*. North-Holland, 31(8–9), pp. 1257–1274. doi: 10.1016/S0048-7333(02)00062-8.

Geels, F. W. (2004) 'From sectoral systems of innovation to socio-technical systems: Insights about dynamics and change from sociology and institutional theory', *Research Policy*. North-Holland, 33(6–7), pp. 897–920. doi: 10.1016/J.RESPOL.2004.01.015.

Geels, F. W. (2005) 'Processes and patterns in transitions and system innovations: Refining the co-evolutionary multi-level perspective', *Technological Forecasting and Social Change*. North-Holland, 72(6), pp. 681–696. doi: 10.1016/J.TECHFORE.2004.08.014.

Geels, F. W. (2010) 'Ontologies, socio-technical transitions (to sustainability), and the multi-level perspective', *Research Policy*. North-Holland, 39(4), pp. 495–510. doi: 10.1016/J.RESPOL.2010.01.022.

Genta, G. (2014) 'Private space exploration: A new way for starting a spacefaring society?', *Acta Astronautica*. Pergamon, 104(2), pp. 480–486. doi: 10.1016/j.actaastro.2014.04.008.

Genus, A. and Coles, A.-M. (2008) 'Rethinking the multi-level perspective of technological transitions', *Research Policy*. North-Holland, 37(9), pp. 1436–1445. doi: 10.1016/J.RESPOL.2008.05.006.

Georghiou, L. (1993) *National Systems of Innovation. Towards a Theory of Innovation and Interactive Learning* edited by Bengt-Ake Lundvall*(Pinter Publishers, London. 1992) pp. xiii + 342, £45, ISBN 1-85567-063-1*, *Prometheus*. Edited by B. A. Lundvall. London: Pinter. doi: 10.1080/08109029308629360.

Gertler, M. S. and Levitte, Y. M. (2005) 'Local Nodes in Global Networks: The Geography of Knowledge Flows in Biotechnology Innovation', *Industry & Innovation*. Taylor & Francis , 12(4), pp. 487–507. doi: 10.1080/13662710500361981.

Gianelle, C. *et al.* (2016) *Implementing Smart Specialisation Strategies: A Handbook*. Luxembourg. doi: 10.2791/53569.

Gieryn, T. F. (1983) 'Boundary-Work and the Demarcation of Science from Non-Science: Strains and Interests in Professional Ideologies of Scientists', *American Sociological Review*, 48(6), p. 781. doi: 10.2307/2095325.

Giuliani, E. (2007a) ‘The selective nature of knowledge networks in clusters: Evidence from the wine industry’, *Journal of Economic Geography*, 7(2), pp. 139–168. doi: 10.1093/jeg/lbl014.

Giuliani, E. (2007b) ‘Towards an understanding of knowledge spillovers in industrial clusters’, *Applied Economics Letters*, 14(2), pp. 87–90. doi: 10.1080/13504850500425907.

Giuliani, E. and Bell, M. (2005) ‘The micro-determinants of meso level learning and innovation: evidence from a Chilean wine cluster’, *Research Policy*, 34(1), pp. 47–68.

Godin, B. (2006) ‘The Linear Model of Innovation: The Historical Construction of an Analytical Framework Science, Technology & Human Values’, *Science, Technology, & Human Values*, 31(6), pp. 639–667.

Grady, M. (2017) ‘Private companies are launching a new space race – here’s what to expect’, *The Conversation*, October. Available at: http://theconversation.com/private-companies-are-launching-a-new-space-race-heres-what-to-expect-80697 (Accessed: 21 March 2019).

Green, K. *et al.* (1999) ‘The construction of the techno-economic: Networks vs. paradigms’, *Research Policy*, 28(7), pp. 777–792.

Gregson, G., Mann, S. and Harrison, R. (2013) ‘Business Angel Syndication and the Evolution of Risk Capital in a Small Market Economy: Evidence from Scotland’, *Managerial and Decision Economics*. John Wiley & Sons, Ltd, 34(2), pp. 95–107. doi: 10.1002/mde.2595.

Griffin, A. (1997) ‘PDMA Research on New Product Development Practices: Updating Trends and Benchmarking Best Practices’, *Journal of Product Innovation Management*. John Wiley & Sons, Ltd (10.1111), 14(6), pp. 429–458. doi: 10.1111/1540-5885.1460429.

Grillitsch, M. (2016) ‘Institutions, smart specialisation dynamics and policy’, *Environment and Planning C: Government and Policy*, 34, pp. 22–37. doi: 10.1177/0263774X15614694.

Grimard, M. (2012) ‘Will the US remain the real leader of human space exploration? A comparative assessment of space exploration policies’, *Acta Astronautica*. Pergamon, 75, pp. 1–14. doi: 10.1016/J.ACTAASTRO.2012.01.007.

Grindley, P., Mowery, D. C. and Silverman, B. (1994) ‘SEMATECH and Collaborative Research: Lessons in the Design of High-Technology Consortia’, *Journal of Policy Analysis and Management*, 13(4), p. 723. doi: 10.2307/3325495.

Gulliver, B. and Finger, W. (2010) ‘Can Your Airport Become a Spaceport? The Benefits of a Spaceport Development Plan’, in *48th AIAA Aerospace Sciences Meeting Including the New Horizons Forum and Aerospace Exposition*. Reston, Virigina: American Institute of Aeronautics and Astronautics. doi: 10.2514/6.2010-1347.

Hackett, S. M. and Dilts, D. M. (2004) ‘A Systematic Review of Business Incubation Research’, *The Journal of Technology Transfer*, 29(1), pp. 55–82. doi: 10.1023/B:JOTT.0000011181.11952.0f.

Haidt, J. (2012) *The righteous Mind: Why People are Divided by Politcis and Religion*. London: Penguin.

Hajian, B. and White, T. (2011) 'Modelling Influence in a Social Network: Metrics and Evaluation', in *2011 IEEE Third Int'l Conference on Privacy, Security, Risk and Trust and 2011 IEEE Third Int'l Conference on Social Computing*. IEEE, pp. 497–500. doi: 10.1109/PASSAT/SocialCom.2011.118.

Hanas, O., Toonder, P. and Pennypacker, F. (1981) 'An Addressable Satellite Encryption System for Preventing Signal Piracy', *IEEE Transactions on Consumer Electronics*, CE-27(4), pp. 631–636. doi: 10.1109/TCE.1981.273532.

Hanley, A., Liu, W. H. and Vaona, A. (2015) 'Credit depth, government intervention and innovation in China: evidence from the provincial data', *Eurasian Business Review*, 5(1), pp. 73–98. doi: 10.1007/s40821-015-0016-2.

Hannon, M. J., Skea, J. and Rhodes, A. (2014) 'Facilitating and coordinating UK energy innovation through systemic innovation intermediaries', in *International Conference on Sustainability Transitions*, pp. 27–29. Available at: https://workspace.imperial.ac.uk/rcukenergystrategy/Public/publications/Hannon (Accessed: 20th).

Hansen, M. and Birkinshaw, J. (2006) 'The Innovation Value Chain: A logic for Fixing Your Company's Innovation Problems', *Harvard Business Review*, pp. 1–16. Available at: http://facultyresearch.london.edu/docs/sim50.pdf.

Hargreaves, T. *et al.* (2012) 'Exploring the roles of intermediaries in UK community energy: Grassroots innovations and niche development', *Science, Society & Sustainability*, 23(5), pp. 1–26. Available at: http://s3.amazonaws.com/academia.edu.documents/33927573/Hargreaves_et_al_2012_Exploring_the_role_of_intermediaries_in_UK_community_energy.pdf?AWSAccessKeyId=AKIAIWOWYYGZ2Y53UL3A&Expires=1488629573&Signature=LO37S1wPopN5ATpSeXdvYjo%2BCaA%3D&response-conten.

Harmancioglu, N. *et al.* (2007) 'Your new product development (NPD) is only as good as your process: an exploratory analysis of new NPD process design and implementation', *R&D Management*. John Wiley & Sons, Ltd (10.1111), 37(5), pp. 399–424. doi: 10.1111/j.1467-9310.2007.00486.x.

Harris, L. (2018) *Developments in the Space Sector in Scotland*, *ICAEW*. Available at: https://www.icaew.com/about-icaew/news/press-release-archive/2018-press-releases/regions-2018/developments-in-the-space-sector-in-scotland.

Harris, R. and Baumann, I. (2015) 'Open data policies and satellite Earth observation', *Space Policy*. Elsevier, 32, pp. 44–53. doi: 10.1016/J.SPACEPOL.2015.01.001.

Harrison, R. L. I. (2013) 'Using mixed methods designs in the Journal of Business Research, 1990–2010', *Journal of Business Research*, 66, pp. 2153–2162.

Harrison, R. T. *et al.* (2010) 'The early-stage risk capital market in Scotland since 2000: issues of scale, characteristics and market efficiency', *Venture Capital*. Routledge , 12(3), pp. 211–

239. doi: 10.1080/13691066.2010.486149.

Hartley, J. (2004) ‘Case Study Research’, in Cassell, C. and Symon, G. (eds) *Essential Guide to Qualitative Methods in Organizational Research*. 1 Oliver’s Yard, 55 City Road, London EC1Y 1SP United Kingdom: SAGE Publications Ltd, pp. 323–333. doi: 10.4135/9781446280119.n26.

Harvey, B. (2003) *Europe’s Space Programme: To Ariane and Beyond*. Edited by B. Harvey. London: Springer. Available at: https://books.google.it/books?hl=it&lr=&id=kYZBLzW7r4cC&oi=fnd&pg=PR13&dq=%22agenzia+spaziale+italiana%22+%22italian+space+agency%22+-ASDC&ots=5WogUMYM8z&sig=evK_wZlbIygK7HOCdXp4V3OK2YY.

Harvey, L. (2014) *Social Research Glossary: Interview*. accessed:, *Quality Research International*. accessed: Quality Research International, [Available at. Available at: http://www.qualityresearchinternational.com/socialresearch/interview.htm#semistructuredinterview.

Haug, P. (1986) ‘US high technology multinationals and Silicon Glen’, *Regional Studies*. Taylor & Francis Group , 20(2), pp. 103–116. doi: 10.1080/09595238600185091.

Hausmann, R. and Rodrik, D. (2003) ‘Economic development as self-discovery’, *Journal of Development Economics*. North-Holland, 72(2), pp. 603–633. doi: 10.1016/S0304-3878(03)00124-X.

Haythornthwaite, C. and Wellman, B. (1996) ‘Using SAS to Convert Ego-Centred Networks to Whole Networks’, *Bulletin of Sociological Methodology/Bulletin de Méthodologie Sociologique*, 50(1), pp. 71–83. doi: 10.1177/075910639605000106.

Hazelrigg, G. A. and Hymowitz, M. E. (1985) ‘Space commercialization: Lessons from history’, *Space Policy*. Elsevier, 1(2), pp. 187–201. doi: 10.1016/0265-9646(85)90072-4.

Hekkert, M. P. *et al.* (2007) ‘Functions of innovation systems: A new approach for analysing technological change’, *Technological Forecasting and Social Change*, 74(4), pp. 413–432. doi: 10.1016/j.techfore.2006.03.002.

Helfat, C. E. and Quinn, J. B. (2006) *Open Innovation: The New Imperative for Creating and Profiting from TechnologyOpen Innovation: The New Imperative for Creating and Profiting from TechnologyBy ChesbroughHenry. Boston, MA: Harvard Business School Press, 2003. 227 pages, hard cover, $35.00*, *Academy of Management Perspectives*. Boston: Harvard Business Press. doi: 10.5465/amp.2006.20591014.

Herstad, S. J., Sandven, T. and Ebersberger, B. (2015) ‘Recruitment, knowledge integration and modes of innovation’, *Research Policy*. North-Holland, 44(1), pp. 138–153. doi: 10.1016/J.RESPOL.2014.06.007.

Hinloopen, J. (2004) ‘The Market for Knowledge Brokers’, *Small Business Economics*. Kluwer Academic Publishers, 22(5), pp. 407–415. doi: 10.1023/B:SBEJ.0000022210.10016.28.

von Hippel, E. (2009) ‘Democratizing Innovation : The Evolving Phenomenon of User Innovation 1’, *Journal für Betriebswirtschaft*, 55(1), pp. 63–78.

Hirsch, J. (2015) 'Elon Musk's growing empire is fueled by $4.9 billion in government subsidies', *Los Angeles Times*, 30 May. Available at: https://www.latimes.com/business/la-fi-hy-musk-subsidies-20150531-story.html.

HM Government (2015) *National Space Policy*. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/484864/NSP_-_Final.pdf (Accessed: 31 March 2019).

HM Government (2017) *Industrial Strategy: building a Britain fit for the future*. London. Available at: www.gov.uk/government/publications (Accessed: 2 February 2019).

HM Government (2018) *Industrial Strategy: Aerospace Sector Deal*. Available at: http://data.parliament.uk/DepositedPapers/Files/DEP2018-1224/BEIS_Aero_Sector_Deal.pdf (Accessed: 1 April 2019).

Holland, D. and Burns, J. O. (2018) 'The American Space Exploration Narrative from the Cold War Through the Obama Administration', *Space Policy*. Elsevier, 46, pp. 9–17. doi: 10.1016/J.SPACEPOL.2018.03.007.

van den Hoonaard, W. C. (2008) 'Sensitizing Concepts', in Given, L. M. (ed.) *The SAGE Encyclopedia of Qualitative Research Methods*. Thousand Oaks, California: SAGE Publications, Inc., pp. 813–815. doi: 10.4135/9781412963909.n422.

Hossain, M. (2017) 'Technological Forecasting & Social Change Motivations , challenges , and opportunities of successful solvers on an innovation intermediary platform', *Technological Forecasting & Social Change*, pp. 0–1. doi: 10.1109/ICEOE.2011.6013395.

Hossain, M. and Kauranen, I. (2016) 'Open innovation in SMEs: a systematic literature review', *Journal of Strategy and Management*, 9(1), pp. 58–73. doi: 10.1108/JSMA-08-2014-0072.

Howell, E. (2018) *SpaceX's Dragon: First Private Spacecraft to Reach Space Station*, *Space*. Available at: https://www.space.com/18852-spacex-dragon.html (Accessed: 14 March 2019).

Howells, J. (2006) 'Intermediation and the role of intermediaries in innovation', *Research Policy*, 35(5), pp. 715–728. doi: 10.1016/j.respol.2006.03.005.

Hu, Y. (2005) 'Efficient, High-Quality Force-Directed Graph Drawing', *Mathematica Journal* , 10(1), pp. 37–71. Available at: https://www.mathematica-journal.com/issue/v10i1/contents/graph_draw/graph_draw.pdf (Accessed: 15 April 2019).

Huang, F. and Rice, J. (2009) 'The Role of Absorptive Capacity in Facilitating "Open Innovation" Outcomes: A Study of Australian SMEs in The Manufacturing Sector', *International Journal of Innovation Management*. Imperial College Press, 13(02), pp. 201–220. doi: 10.1142/S1363919609002261.

Human, S. E. and Provan, K. G. (2000) 'Legitimacy Building in the Evolution of Small-Firm Multilateral Networks: A Comparative Study of Success and Demise', *Administrative Science Quarterly*. SAGE Publications, 45(2), p. 327. doi: 10.2307/2667074.

Hyysalo, S. (2009) *Software and Organizations: The Biography of the Packaged Enterprise System or How SAP Conquered the World*, *Social Studies of Science*. London: Routledge. doi: 10.1177/0306312709335847.

Hyysalo, S., Pollock, N. and Williams, R. (2016) 'Biographies of Artifacts and Practices Approach: Overview and Assessment', in *EASST/4S 2016*. Barcelona, pp. 1–49. Available at: https://edinburghissti.files.wordpress.com/2016/10/boap-methodology-review-20-9-2016.pdf (Accessed: 5 April 2019).

Hyysalo, S., Pollock, N. and Williams, R. A. (2019) 'Method Matters in the Social Study of Technology: Investigating the Biographies of Artifacts and Practices', *Science & Technology Studies*. Science and Technology Studies, 32(3), pp. 2–25. doi: 10.23987/sts.65532.

Hyysalo, S. and Stewart, J. (2008) 'Intermediaries, Users and Social Learning in Technological Innovation', *International Journal of Innovation Management*, 12(03), pp. 295–325. doi: 10.1142/S1363919608002035.

Inkpen, A. C. and Tsang, E. W. K. (2005) 'Social Capital, Networks, and Knowledge Transfer', *The Academy of Management Review*, 30(1), pp. 146–165. doi: 10.5465/AMR.2005.15281445.

Isaksen, A. (2012) 'Building national and regional innovation systems: Institutions for economic development - By Jorge Niosi', *Papers in Regional Science*. Edward Elgar Publishing, 91(2), pp. 473–475. doi: 10.1111/j.1435-5957.2012.00430.x.

Iturrioz, C., Aragón, C. and Narvaiza, L. (2015) 'How to foster shared innovation within SMEs' networks: Social capital and the role of intermediaries', *European Management Journal*. Pergamon, 33(2), pp. 104–115. doi: 10.1016/j.emj.2014.09.003.

Jackson, E. T. (2013) 'Journal of Sustainable Finance & Interrogating the theory of change : evaluating impact investing where it matters most', *Journal of sustainable finance and investment*, 3(August), pp. 37–41. doi: 10.1080/20430795.2013.776257.

Jaruzelski, B., Loehr, J. and Holman, R. (2011) 'Why culture is key', *Strategy and Business*, 65(1), pp. 1–17. Available at: http://www.innovating.com/wordpress/wp-content/uploads/BoozCo_Global_Innovation_1000_2011_Culture_Key.pdf (Accessed: 28 February 2019).

Johannsson, M. *et al.* (2015) 'Space and Open Innovation: Potential, limitations and conditions of success', *Acta Astronautica*. Pergamon, 115, pp. 173–184. doi: 10.1016/J.ACTAASTRO.2015.05.023.

Jolly, S. (2006) *A Europe of Regions: Regional Integration, Sub-National Mobilisation and the Optimal Size of States*. Duke University. Available at: https://sethkjolly.com/files/diss.pdf (Accessed: 15 January 2019).

Jones, O. (2006) 'Developing Absorptive Capacity in Mature Organizations', *Management Learning*. Sage PublicationsSage CA: Thousand Oaks, CA, 37(3), pp. 355–376. doi: 10.1177/1350507606067172.

Jorgensen, D. L. (2015) 'Participant Observation', in *Emerging Trends in the Social and*

Behavioral Sciences. Hoboken, NJ, USA: John Wiley & Sons, Inc., pp. 1–15. doi: 10.1002/9781118900772.etrds0247.

Kareborn, B. B. and Stahlbrost, A. (2009) 'Living Lab: an open and citizen-centric approach for innovation', *International Journal of Innovation and Regional Development*, 1(4), pp. 356–370. doi: 10.1504/IJIRD.2009.022727.

Karo, E. and Kattel, R. (2015) 'Economic development and evolving state capacities in Central and Eastern Europe: can "smart specialization" make a difference?', *Journal of Economic Policy Reform*. Routledge, 18(2), pp. 172–187. doi: 10.1080/17487870.2015.1009068.

Karo, E. and Kattel, R. (2016) *How to Organize for Innovation: Entrepreneurial State and Organizational Variety*. 86. Available at: http://hum.ttu.ee/wp/paper66.pdf (Accessed: 31 May 2019).

Karo, E., Kattel, R. and Cepilovs, A. (2017) 'Can Smart Specialization and Entrepreneurial Discovery be Organized by the Government? Lessons from Central and Eastern Europe', in Radosevic, S. et al. (eds) *Advances in the Theory and Practice of Smart Specialization*. Academic Press, pp. 269–292. doi: 10.1016/B978-0-12-804137-6.00013-9.

Karo, E. and Looga, L. (2016) 'Understanding institutional changes in economic restructuring and innovation policies in Slovenia and Estonia', *Journal of International Relations and Development*. Palgrave Macmillan UK, 19(4), pp. 500–533. doi: 10.1057/jird.2014.23.

Kasku Jackson, J. and Waldorp, E. (2009) 'Understanding space law: legal framework for space', in Coletta, D. and Pilch, F. T. (eds) *Space and defense policy*. London: Routledge, pp. 81–120. doi: 10.4324/9780203883068-13.

Kattirtzi, M. (2016) 'Providing a "challenge function": Government social researchers in the UK's Department of Energy and Climate Change (2010–2015)', *Palgrave Communications*. Palgrave Macmillan Ltd., 2. doi: 10.1057/palcomms.2016.64.

Katzy, B. *et al.* (2013) 'Innovation intermediaries: A process view on open innovation coordination', *Technology Analysis and Strategic Management*, 25(3), pp. 295–309. doi: 10.1080/09537325.2013.764982.

Kelso, A. (2016) 'UK space policy and the politics of parliamentary debate', *Space Policy*. Elsevier, 35, pp. 43–46. doi: 10.1016/J.SPACEPOL.2016.02.005.

Kemp, R., Schot, J. and Hoogma, R. (1998) 'Regime shifts through processes of niche formation: the approach of strategic niche management', *Technology Analysis and Strategic Management*, 10(2), pp. 175 – 195.

Kerry, C. and Danson, M. (2016) 'Open Innovation, Triple Helix and Regional Innovation Systems', *Industry and Higher Education*, 30(1), pp. 67–78. doi: 10.5367/ihe.2016.0292.

Kilelu, C. W. *et al.* (2011) 'Beyond knowledge brokering: an exploratory study on innovation intermediaries in an evolving smallholder agricultural system in Kenya', *Knowledge Management for Development Journal*, 7(1), pp. 84–108. doi: 10.1080/19474199.2011.593859.

Kim, E. S. (2015) *Facilitating Innovation in SMEs: The Case of Public Intermediaries in South Korea*. The University of Edinburgh. Available at: https://www.era.lib.ed.ac.uk/bitstream/handle/1842/19543/Kim2015.pdf?sequence=2&isAllowed=y (Accessed: 19 February 2019).

King, N. (1992) 'Modelling the innovation process: An empirical comparison of approaches', *Journal of Occupational and Organizational Psychology*. John Wiley & Sons, Ltd (10.1111), 65(2), pp. 89–100. doi: 10.1111/j.2044-8325.1992.tb00487.x.

Kishi, N. (2017) 'Management analysis for the space industry', *Space Policy*. Elsevier, 39–40, pp. 1–6. doi: 10.1016/J.SPACEPOL.2017.03.006.

Kivimaa, P. (2014) 'Government-affiliated intermediary organisations as actors in system-level transitions', *Research Policy*, 43(8), pp. 1370–1380. doi: 10.1016/j.respol.2014.02.007.

Klein Woolthuis, R., Lankhuizen, M. and Gilsing, V. (2005) 'A system failure framework for innovation policy design', *Technovation*. Elsevier, 25(6), pp. 609–619. doi: 10.1016/J.TECHNOVATION.2003.11.002.

Klerkx, L., Álvarez, R. and Campusano, R. (2015) 'The emergence and functioning of innovation intermediaries in maturing innovation systems: The case of Chile', *Innovation and Development*, 5(1), pp. 73–91. doi: 10.1080/2157930X.2014.921268.

Klerkx, L. and Leeuwis, C. (2008) 'Matching demand and supply in the agricultural knowledge infrastructure: Experiences with innovation intermediaries', *Food Policy*. Pergamon, 33(3), pp. 260–276. doi: 10.1016/J.FOODPOL.2007.10.001.

Klewitz, J., Zeyen, A. and Hansen, E. G. (2013) 'Intermediaries driving eco-innovation in SMEs: a qualitative investigation', *European Journal of Innovation Management*, 15(4), pp. 442–467. doi: 10.1108/14601061211272376.

Knapp, A. (2018) 'U.K. Space Agency Awards Lockheed Martin $31 Million To Build Spaceport And Satellite Launch System', *Forbes*, July. Available at: https://www.forbes.com/sites/alexknapp/2018/07/15/uk-space-agency-awards-lockheed-martin-31-million-to-build-spaceport-and-satellite-launch-system/#469170cc2940 (Accessed: 31 March 2019).

Knapp, M. L., Hart, R. P. and Dennis, H. S. (1974) 'An Exploration of Deception As a Communication Construct', *Human Communication Research*, 1(1), pp. 15–29. doi: 10.1111/j.1468-2958.1974.tb00250.x.

Knorr-Cetina, K. (1999) *Epistemic Cultures: How the Sciences Make Knowledge*. Harvard University Press. Available at: http://books.google.co.uk/books?id=0QLsngEACAAJ.

Koen, P. *et al.* (2001) 'Providing Clarity and A Common Language to the "Fuzzy Front End"', *Research-Technology Management*. Taylor & Francis, 44(2), pp. 46–55. doi: 10.1080/08956308.2001.11671418.

Kokshagina, O. and Masson, P. Le (2015) 'Fast-connecting open innovation practices: On the role of intermediaries to accelerate the absorptive capacity function', *ISPIM Conference*, 120, pp. 232–239. Available at:

http://search.proquest.com/openview/7a3a28ef95c7ba7967b826486ad369b0/1?pq-origsite=gscholar&cbl=1796422.

Kolleck, N. (2013) ‘Social network analysis in innovation research: using a mixed methods approach to analyze social innovations’, *European Journal of Futures Research*. Springer Berlin Heidelberg, 1(1), p. 25. doi: 10.1007/s40309-013-0025-2.

Kotnik, P. and Petrin, T. (2017) ‘Implementing a smart specialisation strategy: an evidence-based approach’, *International Review of Administrative Sciences*. SAGE PublicationsSage UK: London, England, 83(1), pp. 85–105. doi: 10.1177/0020852315574994.

Koutsouris, A. (2012) ‘Facilitating Agricultural Innovation Systems: A critical realist approach’, *Studies in Agricultural Economics*, 114(2), pp. 64–70. doi: 10.7896/j.1210.

Kroll, H. (2015) ‘Efforts to Implement Smart Specialization in Practice—Leading Unlike Horses to the Water’, *European Planning Studies*. Routledge, 23(10), pp. 2079–2098. doi: 10.1080/09654313.2014.1003036.

Kroll, H. (2019) ‘Eye to eye with the innovation paradox: why smart specialization is no simple solution to policy design’, *European Planning Studies*. Routledge, 27(5), pp. 932–951. doi: 10.1080/09654313.2019.1577363.

Kuhlmann, S. and Rip, A. (2016) ‘Grand societal and economic challenges: a challenge for key actors in the Norwegian knowledge and innovation system’, *Forskningspolitikk*, 2016(1), pp. 13----.

Kyle, E. (2016) ‘Space Launch Report’, *Space Launch Report*, p. 1. Available at: http://www.spacelaunchreport.com/.

Last week’s poll: what do you think of the UK spaceport plan (2018) *The Engineer*. Available at: https://www.theengineer.co.uk/poll-scottish-uk-spaceport/ (Accessed: 2 April 2019).

Latour, B. (1983) ‘Give Me a Laboratory andI will Raise the World’, in *Science observed*, pp. 141--170. Available at: http://scholar.googleusercontent.com/scholar?q=cache:XGn0sZYdUAEJ:scholar.google.com/+give+me+a+laboratory+and+i+will+raise+the+world&hl=en&as_sdt=0,5.

Latour, B. (1988) *The pasteurization of France*. Harvard University Press. Available at: https://books.google.co.uk/books?id=J26KoKtyTxkC&dq=latour+bruno+1993&lr=&source=gbs_navlinks_s.

Launius, R. D. (2003) ‘Evolving public perceptions of spacelight in American culture’, *Acta Astronautica*. Pergamon, 53(4–10), pp. 823–831. doi: 10.1016/S0094-5765(03)00119-X.

Lazaric, N., Longhi, C. and Thomas, C. (2008) ‘Gatekeepers of knowledge versus platforms of Knowledge: From potential to realized absorptive capacity’, *Regional Studies*, 42(6), pp. 837–852. doi: 10.1080/00343400701827386.

Leach, N. (2014) ‘Terrestrial Space Architecture’, *Architectural Design*. John Wiley & Sons, Ltd, 84(6), pp. 54–63. doi: 10.1002/ad.1833.

Lee, C.-M. *et al.* (eds) (2000) *The Silicon Valley edge : a habitat for innovation and entrepreneurship*. Stanford University Press. Available at: https://books.google.co.uk/books?hl=en&lr=&id=eK52augjU98C&oi=fnd&pg=PR15&dq=innovation+culture+silicon+valley&ots=1FDX0luHI0&sig=Ps3kil7M8t7fG3qxz6c4eaaHkh0#v=onepage&q=innovation culture silicon valley&f=false (Accessed: 28 February 2019).

Lee, S. *et al.* (2010) 'Open innovation in SMEs-An intermediated network model', *Research Policy*, 39(2), pp. 290–300. doi: 10.1016/j.respol.2009.12.009.

Leibovitz, J. (2004) '"Embryonic" knowledge-based clusters and cities: The case of biotechnology in Scotland', *Urban Studies*. Sage PublicationsSage UK: London, England, 41(5–6), pp. 1133–1155. doi: 10.1080/00420980410001675805.

Lemaire, J.-P. (2010) 'Local Authorities and Foreign Companies: The Paradoxical Issue of FDI Towards Fast-Growing Economies', in Milliot, E. and Tournois, N. (eds) *The Paradoxes of Globalisation*. Palgrave Macmillan, pp. 43–66. Available at: https://link.springer.com/content/pdf/10.1057%2F9780230303966_4.pdf (Accessed: 28 April 2019).

Leminen, S., Westerlund, M. and Nyström, A.-G. A. (2012) 'Living Labs as open-innovation networks', *Technology Innovation Management Re*. Talent First Network, 2(September), pp. 6–11. Available at: https://timreview.ca/article/602 (Accessed: 15 January 2019).

Levén, P. and Holmström, J. (2008) 'Consumer co-creation and the ecology of innovation: A Living Lab approach', in *Proceedings of IRIS31, August*, pp. 10–13. doi: 10.1080/13662710802373783.

Lewin, A. Y., Massini, S. and Peeters, C. (2011) 'Microfoundations of Internal and External Absorptive Capacity Routines', *Organization Science*, 22(1), pp. 81–98. doi: 10.1287/orsc.1100.0525.

Leydesdorff, L. and Etzkowitz, H. (1995) 'The Triple Helix - University-Industry-Government relations: a laboratory for knowledge base economics development', *EASST Review*, 14(1), pp. 14–19. Available at: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2480085 (Accessed: 10 December 2019).

Lichtenthaler (2013) 'Markets for technology : The definition', *Journal of Product Innovation Management*, 30, pp. 1–9.

Lichtenthaler, U. (2008) 'Open Innovation in Practice: An Analysis of Strategic Approaches to Technology Transactions', *IEEE Transactions on Engineering Management*, 55(1), pp. 148–157. doi: 10.1109/TEM.2007.912932.

Lichtenthaler, U. and Lichtenthaler, E. (2009) 'A capability-based framework for open innovation: Complementing absorptive capacity', *Journal of Management Studies*, 46(8), pp. 1315–1338. doi: 10.1111/j.1467-6486.2009.00854.x.

Lim, D. (2016) 'Small launcher market survey', *Room: The Space Journal*, 3(9). Available at: https://room.eu.com/article/small-launcher-market-survey (Accessed: 28 March 2019).

Lin, H. *et al.* (2016) 'How do intermediaries drive corporate innovation? A moderated mediating examination', *Journal of Business Research*, 69(11), pp. 4831–4836. doi: 10.1016/j.jbusres.2016.04.039.

Liu, X. (2018) 'Interviewing Elites', in James A. H, J. F. G. (ed.) *International Journal of Qualitative Methods*. Oaks, CA: Sage, p. 160940691877032. doi: 10.1177/1609406918770323.

Löfsten, H. and Lindelöf, P. (2002) 'Science Parks and the growth of new technology-based firms - Academic-industry links, innovation and markets', *Research Policy*, 31(6), pp. 859–876. doi: 10.1016/S0048-7333(01)00153-6.

Lombardi, E. (2016) *The Organisation of the Space Sector in Italy: A focus on the Lazio Region*. Lazio.

London Economics (2009) 'The Case for Space 2009', p. 34. Available at: http://www.parliamentaryspacecommittee.com/media/publications/The.

London Economics (2014) *The Size and Health of UK Space Industry*. London. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/363904/SandH2014final2.pdf (Accessed: 15 January 2019).

London Economics (2015a) *Development of the Scottish Space Industry*. Edinburgh. Available at: https://www.space-network.scot/images/downloads/reports/LE_SE_Scottish_Space_Industry.pdf (Accessed: 15 January 2019).

London Economics (2015b) *The Case for Space 2015*. accessed:, *London Economics*. accessed: Available at: http://www.ukspace.org/wp-content/uploads/2015/07/LE-Case-for-Space-2015-Full-Report.pdf.

London Economics (2016) 'The Size and Health of the UK Space Industry 2016'. London. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/575769/Size_and_Health_summary_report_2016.pdf (Accessed: 15 January 2019).

London Economics (2019) *Size and Health of the UK Space Industry 2018*. London. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/774450/LE-SHUKSI_2018-SUMMARY_REPORT-FINAL-Issue4-S2C250119.pdf (Accessed: 2 February 2019).

Lopez-Vega, H. (2009) 'How demand-driven Technological Systems of Innovation work? The role of Intermediary organizations', in *DRUID-DIME Academy PhD Conference*.

Love, J. H. and Roper, S. (2015) 'SME innovation, exporting and growth: A review of existing evidence', *International Small Business Journal: Researching Entrepreneurship*. SAGE PublicationsSage UK: London, England, 33(1), pp. 28–48. doi: 10.1177/0266242614550190.

Lukkarinen, J. *et al.* (2018) 'An intermediary approach to technological innovation systems (TIS)—The case of the cleantech sector in Finland', in *Environmental Innovation and Societal*

Transitions, pp. 136–146. doi: 10.1016/j.eist.2017.04.003.

Lundvall, B.-Å. *et al.* (1992) *National systems of innovation : towards a theory of innovation and interactive learning*, *Research Policy*. London: Pinter. doi: 10.1080/08109029308629360.

Lundvall, B.-Å. *et al.* (2009) 'Bridging Innovation System Research and Development Studies: challenges and research opportunities', in *7th Globelics Conference*. Available at: https://smartech.gatech.edu/bitstream/handle/1853/36669/1238411147_BL.pdf?sequence=1&isAllowed=y (Accessed: 24 April 2019).

Lundvall, B. Å. *et al.* (2002) 'National systems of production, innovation and competence building', *Research Policy*, 31(2), pp. 213–231. doi: 10.1016/S0048-7333(01)00137-8.

Lundvall, B. Å. (2007) 'National innovation systems - Analytical concept and development tool', *Industry and Innovation*, 14(1), pp. 95–119. doi: 10.1080/13662710601130863.

Lundy, P. and McGovern, M. (2006) 'Participation,Truth and Partiality: Participatory Action Research, Community-based Truth-telling and Post-conflict Transition in Northern Ireland', pp. 71–88. doi: 10.1177/0038038506058431.

Macdonald, K. (2017) *Scottish space industry soaring high*, *BBC News*. Available at: http://www.bbc.co.uk/news/38804310.

Macdonald, M. (2019) 'State of the Scottish Nation's Space Sector', in *Proceedings of NSSC*. Edinburgh. Available at: https://medium.com/@malcoluim/state-of-the-scottish-nations-space-sector-faead692c979 (Accessed: 22 March 2019).

Macdonald, M. and Lowe, C. J. (2014) 'It's hip to be square : The CubeSat revolution', *Aerospace*. Royal Aeronautical Society, pp. 22–25. Available at: https://strathprints.strath.ac.uk/46617/ (Accessed: 31 March 2019).

Malerba, F. (2002) 'Sectoral systems of innovation and production', *Research Policy*, 31(2), pp. 247–264. Available at: http://www.sciencedirect.com/science/article/B6V77-459H02Y-5/2/805c2d6a3af53b43a33f2a221520a7f0.

Malerba, F. (2004b) *Sectoral systems of innovation: Concepts, issues and analyses of six major sectors in Europe*, *Sectoral Systems of Innovation: Concepts, Issues and Analyses of Six Major Sectors in Europe*. Cambridge: Cambridge University Press. doi: 10.1017/CBO9780511493270.

Malerba, F. (2005) 'Sectoral systems of innovation: a framework for linking innovation to the knowledge base, structure and dynamics of sectors', *Economics of Innovation and New Technology*, 14(1–2), pp. 63–82. doi: 10.1080/1043859042000228688.

Malerba, F. (2006) 'Innovation and the evolution of industries', *Journal of Evolutionary Economics*, 16(1–2), pp. 3–23. doi: 10.1007/s00191-005-0005-1.

Malerba, F. (2007) 'Innovation and the dynamics and evolution of industries: Progress and challenges', *International Journal of Industrial Organization*, 25(4), pp. 675–699. doi: 10.1016/j.ijindorg.2006.07.005.

Malerba, F. *et al.* (2016) 'Innovation and the evolution of industries: History-friendly models', *Innovation and the Evolution of Industries: History-Friendly Models*, 172(July), pp. 1–274. doi: 10.1017/CBO9781107280120.

Malerba, F. and Orsenigo, L. (1990) 'Technological Regimes and Patterns of Innovation: A Theoretical and Empirical Investigation of the Italian Case', in Heertje, A. and Perlman, M. (eds) *Evolving Technology and Market Structure - Studies in Schumpeterian Economics*. University of Michigan Press, pp. 283–305. Available at: https://books.google.co.uk/books?hl=en&lr=&id=qQMOPjUgWHsC&oi=fnd&pg=PA283&dq=Technological+regimes+and+patterns+of+innovation:+a+theoretical+and+empirical+investigation+of+the+Italian+case&ots=d2eZReT6VY&sig=q60EV9MzPexb6SNVnVO4S9cDufo (Accessed: 27 April 2019).

Malerba, F. and Orsenigo, L. (1995) 'Schumpeterian patterns of innovation', *Cambridge Journal of Economics*, 19(1), pp. 47–65. doi: 10.1093/oxfordjournals.cje.a035308.

Malerba, F. and Orsenigo, L. (1997) 'Technological Regimes and Sectoral Patterns of Innovative Activities', *Industrial and Corporate Change*. Narnia, 6(1), pp. 83–118. doi: 10.1093/icc/6.1.83.

Malerba, Franco (2004a) *Sectoral System of Innovation - concepts, issues and analyzes of the six major sectors in Europe*. Edited by F Malerba. Cambridge: Cambridge University Press.

Marabelli, M. and Newell, S. (2014) 'Knowing, Power and Materiality: A Critical Review and Reconceptualization of Absorptive Capacity', *International Journal of Management Reviews*, 16(4), pp. 479–499. doi: 10.1111/ijmr.12031.

Markard, J. and Truffer, B. (2008) 'Technological innovation systems and the multi-level perspective: Towards an integrated framework', *Research Policy*. North-Holland, 37(4), pp. 596–615. doi: 10.1016/J.RESPOL.2008.01.004.

Markides, C. C. and Anderson, J. (2006) 'Creativity is not enough: ICT-enabled strategic innovation', *European Journal of Innovation Management*. Emerald Group Publishing Limited, 9(2), pp. 129–148. doi: 10.1108/14601060610663532.

Markman, G. D. *et al.* (2005) 'Entrepreneurship and university-based technology transfer', *Journal of Business Venturing*, 20(2), pp. 241–263. doi: 10.1016/j.jbusvent.2003.12.003.

Markman, G. D., Siegel, D. S. and Wright, M. (2008) 'Research and technology commercialization', *Journal of Management Studies*, 45(8), pp. 1401–1423. doi: 10.1111/j.1467-6486.2008.00803.x.

Marsden, P. V (2002) 'Egocentric and sociocentric measures of network centrality', *Social Networks*. North-Holland, 24(4), pp. 407–422. doi: 10.1016/S0378-8733(02)00016-3.

Marshall, N. and Rollinson, J. (2004) 'Maybe Bacon Had a Point: The Politics of Interpretation in Collective Sensemaking1', *British Journal of Management*, 15(S1), pp. 71–86. doi: 10.1111/j.1467-8551.2004.00407.x.

Martin, B. R. (2016) 'Twenty challenges for innovation studies', *Science and Public Policy*. Oxford University Press, 43(3), pp. 432–450. doi: 10.1093/scipol/scv077.

Martin, S., Pahor, M. and Jaklič, M. (2015) 'The structure of policy-induced innovation networks in Slovenia', *European Journal of Innovation Management*. Edited by D. Carl Abbott and Professor James A., 18(4), pp. 428–450. doi: 10.1108/EJIM-09-2013-0093.

Martin, S. and Scott, J. T. J. T. (2000) 'The nature of innovation market failure and the design of public support for private innovation', *Research Policy*, 29(4–5), pp. 437–447. doi: 10.1016/S0048-7333(99)00084-0.

Maryniak, G. (2005) 'When will we see a Golden Age of Spaceflight?', *Space Policy*. Elsevier, 21(2), pp. 111–119. doi: 10.1016/J.SPACEPOL.2005.04.004.

Mason, C. M. and Harrison, R. T. (2015) 'Business angel investment activity in the financial crisis: UK evidence and policy implications', *Environment and Planning C: Government and Policy*, 33, pp. 43–60. doi: 10.1068/c12324b.

Mastroeni, M. *et al.* (2017) 'Science and innovation dynamics and policy in Scotland: The perceived impact of enhanced autonomy', *International Journal of Technology Management & Sustainable Development*, 16(1), pp. 3–24. doi: 10.1386/tmsd.16.1.3_1.

Mazzoleni, R. and Nelson, R. R. (2007) 'Public research institutions and economic catch-up', *Research Policy*. North-Holland, 36(10), pp. 1512–1528. doi: 10.1016/j.respol.2007.06.007.

Mccann, P. and Ortega-argilés, R. (2017) 'Smart Specialization , Regional Growth and Applications to European Union Cohesion Policy Smart Specialization , Regional Growth and Applications to European Union Cohesion Policy', *Policy, Regional Studies*, 3404(February), pp. 1291–1302. doi: 10.1080/00343404.2013.799769.

Mccann, P. and Ortega-Argilés, R. (2014) 'Smart specialisation in European regions: issues of strategy, institutions and implementation', *European Journal of Innovation Management*, 17, pp. 583–596. doi: 10.1108/EJIM-05-2014-0052.

McCann, P. and Ortega-Argilés, R. (2015) 'Smart Specialization, Regional Growth and Applications to European Union Cohesion Policy', *Regional Studies*, 49(8), pp. 1291–1302. doi: 10.1080/00343404.2013.799769.

Mccleskey, C. M. (1999) 'Strategic Space Launch Concept and Technology Roadmaps to Develop Visionary Spaceports FOR THE 50 th International Astronautical Congress', in *50th International Astronautical Congress*. Amsterdam. Available at: http://www.airports.org/traffic/index.html (Accessed: 28 March 2019).

McCulloch Scott (2016) 'Scottish electronics firm Optocap sold to German conglomerate - Business Insider', *Insider*. accessed:, p. 34. Available at: https://www.insider.co.uk/news/scottish-electronics-firm-optocap-sold-9866274 (Accessed: 11 August 2018).

McEvily, B. and Zaheer, A. (1999) 'Bridging ties: A source of firm heterogeneity in competitive capabilities', *Strategic Management Journal*, 20(12), pp. 1133–1156. doi: 10.1002/(SICI)1097-0266(199912)20:12<1133::AID-SMJ74>3.0.CO;2-7.

McIntyre, A. (2007) *Participatory action research*. Sage Publications.

McKelvey, M. and Orsenigo, L. (2001) *Pharmaceuticals as a sectoral innovation system*, *ESSY project (European Sectoral Systems of Innovation)*. Milan: A Miemo. Available at: http://www.druid.dk/uploads/tx_picturedb/dw2002-447.

Van Meel, J. and Vos, P. (2001) 'Funky offices: Reflections on office design in the "new economy"', *Journal of Corporate Real Estate*, 3(4), pp. 322–334. doi: 10.1108/14630010110811661.

Mello, R. A. (2002) 'Collocation analysis: a method for conceptualizing and understanding narrative data', *Qualitative Research*. Sage PublicationsSage CA: Thousand Oaks, CA, 2(2), pp. 231–243. doi: 10.1177/146879410200200206.

Van der Meulen, B. *et al.* (2005) *Intermediaries Organisation and Processes : theory and research issues*, *PRIME Workshop*. PRIME Workshop.

Mgumia, A. H., Mattee, A. Z. and Kundi, B. A. T. (2015) 'Contribution of innovation intermediaries in agricultural innovation: The case of agricultural R&D in Tanzania', *African Journal of Science, Technology, Innovation and Development*, 7(2), pp. 151–160. doi: 10.1080/20421338.2015.1023644.

Mian, S. (1996) 'Assessing Value-added Contributions of University Technology Business Incubators to', *Tenant Firms', Research Policy*, 25(3), pp. 325–335.

Mikecz, R. (2012) 'Interviewing Elites: Addressing Methodological Issues', *Qualitative Inquiry*, 18(6), pp. 482–493. doi: 10.1177/1077800412442818.

Mishra, U. K. (2004) 'Satellite Applications', in, pp. 1–21. Available at: https://sa.catapult.org.uk/documents/10625/88741/Satellites.

Moreno, J. *et al.* (2012) 'ESA's sentinel missions in support of Earth system science', *Remote Sensing of Environment*. Elsevier, 120, pp. 84–90. doi: 10.1016/J.RSE.2011.07.023.

Morgan, K. (2017) 'Nurturing novelty: Regional innovation policy in the age of smart specialisation', *Environment and Planning C: Politics and Space*. SAGE PublicationsSage UK: London, England, 35(4), pp. 569–583. doi: 10.1177/0263774X16645106.

Morrisey, C. T. and Morrissey, C. (1998) 'On Oral History Interviewing', in Dexter, L. A. (ed.) *The oral history reader*. Evanston: Northwestern University Press, pp. 107–113.

Müller, M. (2015) 'Assemblages and Actor-networks: Rethinking Socio-material Power, Politics and Space', *Geography Compass*. John Wiley & Sons, Ltd (10.1111), 9(1), pp. 27–41. doi: 10.1111/gec3.12192.

Murden, T. (2017) *Space consortium to monitor tropical forest*, *Daily Business*. Available at: https://dailybusinessgroup.co.uk/2017/01/space-consortium-to-monitor-tropical-forest/ (Accessed: 11 May 2019).

Murfin, T. (2014) 'Hexagon's Acquisition of Veripos: Why Did This Go Down?', *GPS World*.

Musante, K. and DeWalt, B. R. (2010) *Participant observation: A guide for fieldworkers*. Rowman Altamira. Available at:

https://books.google.co.uk/books?hl=en&lr=&id=ymJJUkR7s3UC&oi=fnd&pg=PP1&dq=participant+observation&ots=Uhsq0fFsSb&sig=8pUnGweC-SLCm2GRpaK76RjiNO0 (Accessed: 2 April 2019).

Nath, A. *et al.* (2016) *Space and the Sustainable Development Goals:* Cape Town. Available at: https://www.dropbox.com/s/vov6zhlzqrkwi7w/TP16-02_SAIMSA_2016.pdf?dl=0 (Accessed: 21 March 2019).

Ndou, V. *et al.* (2012) 'Toward a sectoral system of innovation for local wine sector', *Int. J. Business and Globalisation*, 8(1). doi: 10.1504/IJBG.2012.043973.

Neapole, B. (2005) 'New Product Innovation and Development', *Lek*. Los Angeles: L.E.K. Consulting, 2.

Neffke, F. *et al.* (2014) *The role of firms and entrepreneurs in regional diversification*. Utrecht: Utrecht University, Section of Economic Geography. Available at: https://ideas.repec.org/p/egu/wpaper/1410.html.

Nelson, R. R. (1993) *National Innovation Systems: A Comparative Analysis*, *University of Illinois at Urbana-Champaign's Academy …*. IL: University of Illinois. Available at: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1496195.

Nelson, R. R. and Nelson, K. (2002) 'Technology, institutions, and innovation systems', *Research Policy*, 31(2), pp. 265–272. doi: 10.1016/S0048-7333(01)00140-8.

Nelson, R. R. and Winter, S. G. (1982) *An Evolutionary Theory of Economic Change*. Cambridge (MA): The Belknap Press of Harvard University Press. Available at: http://inctpped.ie.ufrj.br/spiderweb/pdf_2/Dosi_1_An_evolutionary-theory-of_economic_change..pdf (Accessed: 27 April 2019).

New Products Management for the 1980s (1982). New York: Booz, Allen and Hamilton. Available at: https://books.google.co.uk/books/about/New_Products_Management_for_the_1980s.html?id=pP8JAQAAMAAJ&redir_esc=y (Accessed: 15 July 2019).

Newlands, E. (2018) 'UK tech booming with Edinburgh scene racing ahead', *The Scotsman*, 17 May. Available at: https://www.scotsman.com/future-scotland/tech/uk-tech-booming-with-edinburgh-scene-racing-ahead-1-4740561 (Accessed: 19 July 2019).

Ngwenya, H. and Hagmann, J. (2011) 'Making innovation systems work in practice: experiences in integrating innovation, social learning and knowledge in innovation platforms', *Knowledge Management for Development Journal*, 7(1), pp. 109–124. doi: 10.1080/19474199.2011.593867.

Nicolini, D. (2011) 'Practice as the Site of Knowing: Insights from the Field of Telemedicine', *Organization Science*, 22(3), pp. 602–620. doi: 10.1287/orsc.1100.0556.

Niederstrasser, C. (2018) 'Small Launch Vehicles: A 2018 State of the Industry Survey', in *32nd Annual AIAA/USU Conference on Small Satellites*, p. 12. Available at: https://digitalcommons.usu.edu/cgi/viewcontent.cgi?article=4118&context=smallsat (Accessed: 28 March 2019).

Nilsson, M. and Sia-Ljungström, C. (2013) 'The Role of Innovation Intermediaries in Innovation Systems', in *2013 International European Forum, February 18-22, 2013, Innsbruck-Igls, Austria*. Innsbruck-Igls: International European Forum on System Dynamics and Innovation in Food Networks, pp. 161–180. Available at: https://ideas.repec.org/p/ags/iefi13/164741.html (Accessed: 19 February 2019).

Nishimura, J. and Okamuro, H. (2011) 'Subsidy and networking: The effects of direct and indirect support programs of the cluster policy', *Research Policy*. North-Holland, 40(5), pp. 714–727. doi: 10.1016/J.RESPOL.2011.01.011.

Nonaka, I., Reinmoeller, P. and Senoo, D. (1998) 'The "ART" of knowledge: Systems to capitalize on market knowledge', *European Management Journal*. Pergamon, 16(6), pp. 673–684. doi: 10.1016/S0263-2373(98)00044-9.

Nutley, S. M., Walter, I. and Davies, H. T. O. (2007) *Using Evidence: How Research Can Inform Public Services*. London: Policy Press. Available at: https://books.google.com/books?hl=en&lr=&id=UfMefp4rO9sC&pgis=1.

Nyqvist, A., Høyer Leivestad, H. and Tunestad, H. (2017) 'Individuals and Industries: Large-Scale Professional Gatherings as Ethnographic Fields', in *Ethnographies of Conferences and Trade Fairs*. Springer International Publishing, pp. 1–21. doi: 10.1007/978-3-319-53097-0_1.

Odendahl, T. and Shaw, M. A. (2002) 'Interviewing Elites', in James A. H, J. F. G. (ed.) *Handbook of Interview Research: Context and Method.* Thousand Oaks, CA: Sage.

OECD (2004) 'Promoting Entrepreneurship and Innovative SMEs in a Global Economy: Towards a more responsible and inclusive globalisation', in *2nd OECD Conference of Ministers Responsible for Small and Medium-Sized Enterprises (SMEs)*. Istambul: OECD, p. 59. Available at: www.oecd.org (Accessed: 31 May 2019).

OECD (2007a) *Oslo Manual*. doi: 10.1787/9789264065659-es.

OECD (2007b) *The Space Economy at a Glance*. OECD Publishing. doi: 10.1787/9789264040847-en.

OECD (2011) *ISIC REV. 3 Technology Intensity Definition - Classification of manufacturing industries into categories based on R&D intensities.* accessed: doi: 10.1787/sti.

OECD (2013) *Innovation-driven Growth in Regions: The Role of Smart Specialisation*. Paris. Available at: https://www.oecd.org/innovation/inno/smart-specialisation.pdf (Accessed: 15 January 2019).

OECD (2014) *The Space Economy at a Glance 2014*. doi: 10.1787/9789264217294-en.

OECD Handbook on Measuring the Space Economy (2012). OECD. doi: 10.1787/9789264169166-en.

Ong, B. K. (2012) 'Grounded Theory Method (GTM) and the Abductive Research Strategy (ARS): A critical analysis of their differences', *International Journal of Social Research Methodology*, 15(5), pp. 417–432. doi: 10.1080/13645579.2011.607003.

Open Access at ESA (2019). Available at: http://open.esa.int/ (Accessed: 29 March 2019).

Ostrander, S. A. (1993) '"Surely you're not in this just to be helpful": Access, Rapport, and Interviews in Three Studies of Elites', in Hertz, R. and B.I., J. (eds) *Journal of Contemporary Ethnography*. CA: SAGE Publications, pp. 7–27. doi: 10.1177/089124193022001002.

Oxford Economics (2010) *The Size and Health of the UK Space Industry A Report for the UK Space Agency*. London. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/298348/10-1195-size-and-health-uk-space-industry-2010.pdf (Accessed: 15 January 2019).

Oxford Economics (2012) *The Size and Health of the UK Space Industry*. London. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/298355/size-and-health-report-oct-2012.pdf (Accessed: 15 January 2019).

Pallegar, A. (2018) *2. Democratizing Innovation: How Consumer Electronics Is Revolutionizing RocketScience*, *International Review of Business and Economics (IRBE)*. Available at: https://www.researchgate.net/publication/323834743 (Accessed: 29 March 2019).

Parida, V., Westerberg, M. and Frishammar, J. (2012) 'Inbound Open Innovation Activities in High-Tech SMEs: The Impact on Innovation Performance', *Journal of Small Business Management*, 50(2), pp. 283–309. doi: 10.1111/j.1540-627X.2012.00354.x.

Parikh, M. (2001) 'Knowledge Management Framework for High-Tech Research and Development', *Engineering Management Journal*. Taylor & Francis, 13(3), pp. 27–34. doi: 10.1080/10429247.2001.11415124.

Pavitt, K. (2003) 'The Process of Innovation', *SPRU Working Paper Series*. SPRU - Science Policy Research Unit, University of Sussex Business School. Available at: https://ideas.repec.org/p/sru/ssewps/89.html.

Pavitt, K. (2006) 'Innovation Processes', in Fagerberg, J., Mowery, D. C., and Nelson, R. R. (eds) *The Oxford Handbook of Innovation*. Oxford: Oxford University Press.

Petroni, G. *et al.* (2013) 'Strategies and determinants for successful space technology transfer', *Space Policy*, 29(4), pp. 251–257. doi: 10.1016/j.spacepol.2013.06.010.

Petroni, G. and Bianchi, D. G. (2016) 'New patterns of space policy in the post-Cold War world', *Space Policy*. Elsevier, 37, pp. 12–19. doi: 10.1016/J.SPACEPOL.2016.10.002.

Petroni, G. and Santini, S. (2012) 'Innovation and change? The evolution of Europe's small satellite manufacturers', *Space Policy*. Elsevier, 28(1), pp. 25–32. doi: 10.1016/J.SPACEPOL.2011.12.008.

Petroni, G. and Verbano, C. (2000) 'The development of a technology transfer strategy in the aerospace industry: the case of the Italian Space Agency', *Technovation*. Elsevier, 20(7), pp. 345–351. doi: 10.1016/S0166-4972(99)00149-2.

Phan, P. H., Siegel, D. S. and Wright, M. (2005) 'Science parks and incubators: Observations, synthesis and future research', *Journal of Business Venturing*, 20(2), pp. 165–182. doi:

10.1016/j.jbusvent.2003.12.001.

Pickering, A. (1995) *The Mangle of Practice: Time, Agency, and Science*. Available at: https://books.google.co.uk/books?id=UGSaDhK4LZEC&q=pragmatic+realism#v=snippet&q=pragmatic realism&f=false (Accessed: 8 December 2019).

Pickles, J. (1995) *Ground truth : the social implications of geographic information systems*. Guilford Press. Available at: https://books.google.co.uk/books?hl=en&lr=&id=8ER-jC1VB90C&oi=fnd&pg=PA1&dq=ground+truth+what+is&ots=rYSAgHo3ny&sig=igZKbVUE4OKOkp6faReQpVmbiCk#v=onepage&q=ground truth what is&f=false (Accessed: 21 March 2019).

Pierson, J. O. and Lievens, B. (2005) 'Configuring Living Labs For A "Thick'' Understanding Of Innovation"', in *Ethnographic Praxis in Industry Conference Proceedings*. Oxford, UK: Blackwell Publishing Ltd, pp. 114–127. doi: 10.1111/j.1559-8918.2005.tb00012.x.

Pittaway, L. *et al.* (2004) 'Networking and innovation: a systematic review of the evidence', *International Journal of Management Reviews*, 5–6(3–4), pp. 137–168. Available at: http://dx.doi.org/10.1111/j.1460-8545.2004.00101.x.

Platt, J. (1981) 'On interviewing one's peers', *British Journal of Sociology*, 32,1(1), pp. 75–91. doi: 10.2307/589764.

Pollock, N. and Williams, R. (2008) *Software and organisations: The biography of the enterprise-wide system or how SAP conquered the world*, *Software and Organisations: The Biography of the Enterprise-Wide System or How SAP Conquered the World*. London: Routledge. doi: 10.4324/9780203891940.

Pollock, N. and Williams, R. (2010) 'E-Infrastructures: How do we know and understand them? Strategic ethnography and the biography of artefacts', *Computer Supported Cooperative Work*, 19(6), pp. 521–556. doi: 10.1007/s10606-010-9129-4.

Polverari, L. (2016) *The Implementation of Smart Specialisation Strategies in 2014-20 ESIF programmes: turning intelligence into performance*. 39.2. Glasgow.

Pomeroy, C., Calzada-Diaz, A. and Bielicki, D. (2019) 'Fund Me to the Moon: Crowdfunding and the New Space Economy', *Space Policy*. Elsevier, 47, pp. 44–50. doi: 10.1016/J.SPACEPOL.2018.05.005.

Porter, M. E. (2000) 'Location, competition, and economic development: Local clusters in a global economy', *Economic Development Quarterly*, 14(1), pp. 15–34. doi: 10.1177/089124240001400105.

Powell, W. W. (2005) 'Networks of innovators', in J., M. D. C. (ed.) *The Oxford handbook of innovation*. Oxford Handbooks Online, pp. 56–85. doi: 10.1093/oxfordhb/9780199286805.003.0003.

Powell, W. W., Koput, K. W. and Smith-Doerr, L. (1996) 'Interorganizational Collaboration and the Locus of Innovation: Networks of Learning in Biotechnology', *Administrative Science Quarterly*, 41(1), p. 116. doi: 10.2307/2393988.

Provan, K. G., Fish, A. and Sydow, J. (2007) ‘Interorganizational Networks at the Network Level: A Review of the Empirical Literature on Whole Networks’, *Journal of Management*, 33(3), pp. 479–516. doi: 10.1177/0149206307302554.

Pullen, A. J. J. J. *et al.* (2012) ‘Open innovation in practice: Goal complementarity and closed NPD networks to explain differences in innovation performance for SMEs in the medical devices sector’, *Journal of Product Innovation Management*, 29(6), pp. 917–934. doi: 10.1111/j.1540-5885.2012.00973.x.

Radosevic, S. and Myrzakhmet, M. (2009) ‘Between vision and reality: Promoting innovation through technoparks in an emerging economy’, *Technovation*. Elsevier, 29(10), pp. 645–656. doi: 10.1016/J.TECHNOVATION.2009.04.001.

Randhawa, K. *et al.* (2017) ‘Knowledge collaboration between organizations and online communities: the role of open innovation intermediaries’, *Journal of Knowledge Management*, 21(6), pp. 1293–1318. doi: 10.1108/JKM-09-2016-0423.

Regulation (EC) No 1059/2003 of the European Parliament and of the Council of 26 May 2003 on the establishment of a common classification of territorial units for statistics (NUTS) (2018). Brussels: European Parliament. Available at: https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:02003R1059-20180118&qid=1519136585935 (Accessed: 30 May 2019).

Reid, A. and Maroulis, N. (2017) ‘From Strategy to Implementation: The Real Challenge for Smart Specialization Policy’, *Advances in the Theory and Practice of Smart Specialization*. Academic Press, pp. 293–318. doi: 10.1016/B978-0-12-804137-6.00012-7.

Reid, A. and Stanovnik, P. (2013) *The development of a Smart Specialisation Strategy (S3) for Slovenia: A Report to the European Commission, DG Research & Innovation*. doi: 10.13140/RG.2.2.30434.32962.

Richards, D. (1996) ‘Elite Interviewing: Approaches and Pitfalls’, *Politics*, 16(3), pp. 199–204. doi: 10.1111/j.1467-9256.1996.tb00039.x.

Rip, A. and Kemp, R. (1998) ‘Technological change’, in Malone, E. L. and Rayner, S. (eds) *Human choice and climate change*. Battelle Press, pp. 327–399. Available at: https://pdfs.semanticscholar.org/4739/5c4a2d310598d1e945873ee3787535df2844.pdf (Accessed: 21 April 2019).

Robbins, P. (2003) ‘Beyond Ground Truth: GIS and the Environmental Knowledge of Herders, Professional Foresters, and Other Traditional Communities’, *Human Ecology*. Kluwer Academic Publishers-Plenum Publishers, 31(2), pp. 233–253. doi: 10.1023/A:1023932829887.

Rodríguez-Pose, A. (2013) ‘Do Institutions Matter for Regional Development?’, *Regional Studies*. Routledge , 47(7), pp. 1034–1047. doi: 10.1080/00343404.2012.748978.

Rodríguez-Pose, A., di Cataldo, M. and Rainoldi, A. (2014) *The Role of Government Institutions for Smart Specialisation and Regional Development*. 04/2014. Brussels.

Roffe, I. (1999) ‘Innovation and creativity in organisations: a review of the implications for training and development', *Journal of European Industrial Training*. MCB UP Ltd, 23(4/5), pp. 224–241. doi: 10.1108/03090599910272103.

Roper, S., Du, J. and Love, J. H. (2008) 'Modelling the innovation value chain', *Research Policy*, 37(6–7), pp. 961–977. doi: 10.1016/j.respol.2008.04.005.

Ross, C. (2019) 'UK Government warned against "procrastination" on space launch regulations | Press and Journal'. Available at: https://www.pressandjournal.co.uk/fp/news/highlands/1700640/uk-government-warned-against-procrastination-on-space-launch-regulations/ (Accessed: 24 December 2019).

Russo, M. and Rossi, F. (2009) 'Cooperation networks and innovation: A complex systems perspective to the analysis and evaluation of a regional innovation policy programme', *Evaluation*, 15(1), pp. 75–99. doi: 10.1177/1356389008097872.

Salter, A. J. and Martin, B. R. (2001) 'The economic benefits of publicly funded basic research: A critical review', *Research Policy*, 30(3), pp. 509–532. doi: 10.1016/S0048-7333(00)00091-3.

Sapsed, J., Grantham, A. and De Fillippi, R. (2007) 'A bridge over troubled waters: Bridging organizations and entrepreneurial opportunities in emerging sectors', *Research Policy*, 36, p. 1314.

Satellite Applications Catapult (2014) *Satellites: The Big Picture*. Harwell. Available at: https://cpb-us-e1.wpmucdn.com/blogs.rice.edu/dist/5/1410/files/2014/12/S4E_Brochure_Amended_Version_2_lo_res2.pdf (Accessed: 28 March 2019).

Satellite Applications Catapult (2018) *Small Satellite Market Intelligence*. Harwell. Available at: https://media.sa.catapult.org.uk/wp-content/uploads/2017/07/07110329/Small_Sat_Market_Intelligence_Q3_2018.pdf (Accessed: 22 January 2019).

Satellite Applications Catapult (2019) *Scottish Space Incubation Programme*. Available at: https://sa.catapult.org.uk/opportunities/scottish-space-incubation-programme/ (Accessed: 31 March 2019).

Schrogl, K.-U. (2017) 'The popularisation of space – A European perspective', *Space Policy*. Elsevier, 41, pp. 70–72. doi: 10.1016/J.SPACEPOL.2017.01.004.

Schurz, G. (2018) 'Optimality justifications: new foundations for foundation-oriented epistemology', *Synthese*. Springer Netherlands, 195(9), pp. 3877–3897. doi: 10.1007/s11229-017-1363-6.

Schuurman, D., De Marez, L. and Ballon, P. (2016) 'The Impact of Living Lab Methodology on Open Innovation Contributions and Outcomes', *Technology Innovation Management Review*, 1(6), pp. 7–16. doi: 10.22215/timreview/956.

Scott, J. (1988) 'Social Network Analysis', *Sociology*, 22(1), pp. 109–127. doi: 10.1177/0038038588022001007.

Scottish Development International (2015) *Nanosatellite & data company Spire choose*

Glasgow for European HQ. Available at: https://www.sdi.co.uk/success-stories/spire (Accessed: 8 May 2019).

Scottish Enterprise (2016a) *Aerospace, Defence, Marine and Security: Industrial Startegy for Scotland 2016*. accessed: Available at: http://www.ukmarinealliance.co.uk/sites/default/files/ADMS.

Scottish Enterprise (2016b) *Development of the Scottish Space Industry*. Available at: https://www.space-network.scot/images/downloads/reports/LE_SE_Scottish_Space_Industry.pdf.

Scottish Enterprise (2018) *A New Approach to Support from Scottish Enterprise*. Available at: https://www.lifesciencesscotland.com/wp-content/uploads/2018/05/SE-innovation-support-and-grants-May18.pdf (Accessed: 1 April 2019).

Scottish Enterprise (2019a) *Regional Selective Assistance (RSA) grants*. Available at: https://www.scottish-enterprise.com/support-for-businesses/funding-and-grants/growing-your-business/regional-selective-assistance-grant (Accessed: 8 May 2019).

Scottish Enterprise (2019b) *SMART: SCOTLAND grant for SMEs*. Available at: https://www.scottish-enterprise.com/support-for-businesses/funding-and-grants/growing-your-business/smart-scotland-grant (Accessed: 6 May 2019).

Sedlack, R. G. and Stanley, J. (1992) *Social research: Theory and methods*. Boston: Allyn and Bacon.

Seidel, U. *et al.* (2013) 'A new approach for analysing national innovation systems in emerging and developing countries', *Industry and Higher Education*, 27(4), pp. 297–285.

Semangdal, R. (2017) *SpaceX Keeps Lining Up Covert Military Launches*, *Wired*. Available at: https://www.wired.com/story/spacex-keeps-lining-up-covert-military-launches/ (Accessed: 14 March 2019).

Shank, G. (2008) 'Abduction', in Given, L. M. (ed.) *The SAGE Encyclopedia of Qualitative Research Methods*. Thousand Oaks California s: SAGE Publications, Inc., pp. 29–2. doi: 10.4135/9781412963909.n1.

Shetland Space Centre (2019) *SSC seals launch site partnership with ArianeGroup*. Available at: https://shetlandspacecentre.com/general/ssc-seals-launch-site-partnership-with-arianegroup/ (Accessed: 2 February 2019).

Shin, M., Holden, T. and Schmidt, R. A. (2001) 'From knowledge theory to management practice: towards an integrated approach', *Information Processing & Management*. Pergamon, 37(2), pp. 335–355. doi: 10.1016/S0306-4573(00)00031-5.

Shirazi, B. (2015) 'Integrative research: Integral epistemology and integrative methodology', *Integral Review*, 11(1), pp. 17–26.

Siegel, D. S., Waldman, D. and Link, A. (2003) 'Assessing the impact of organizational practices on the relative productivity of university technology transfer offices: An exploratory study', *Research Policy*, 32(1), pp. 27–48. doi: 10.1016/S0048-7333(01)00196-2.

Simard, C. (2015) 'Knowledge Networks and the Geographic Locus of Innovation', pp. 220–240.

Simard, C. and West, J. (2006) 'Knowledge Networks and the Geographic Locus of Innovation', in Chesbrough, H., Vanhaverbeke, W., and West, J. (eds) *Open innovation: Researching a new paradigm*. Oxford University Press, pp. 220–240. Available at: https://www.researchgate.net/profile/Joel_West/publication/228355975_Knowledge_networks_and_the_geographic_locus_of_innovation/links/55d1f0a608ae3dc86a4f3554.pdf.

Slovenia's Smart Specialisation Strategy S4 (2017). Ljubljana. Available at: http://www.svrk.gov.si/fileadmin/svrk.gov.si/pageuploads/Dokumenti_za_objavo_na_vstopni_strani/S4_dokument_V_2017EN.pdf (Accessed: 30 May 2019).

Smith, A., Voß, J.-P. and Grin, J. (2010) 'Innovation studies and sustainability transitions: The allure of the multi-level perspective and its challenges', *Research Policy*, 39(4), pp. 435–448. doi: 10.1016/J.RESPOL.2010.01.023.

Smits, R. and Kuhlmann, S. (2004) 'The rise of systemic instruments in innovation policy', *International Journal of Foresight and Innovation Policy*, 1(1/2), p. 4. doi: 10.1504/IJFIP.2004.004621.

Sørensen, K. H. (1996) *Learning technology, constructing culture. Socio-technical change as social learning*. 18/96.

Sorrell, S. (2018) 'Explaining sociotechnical transitions: A critical realist perspective', *Research Policy*. North-Holland, 47(7), pp. 1267–1282. doi: 10.1016/J.RESPOL.2018.04.008.

Space: a new European frontier for an expanding Union - An action plan for implementing the European Space policy (2003). Brussels : European Commission. Available at: https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:52003DC0673:EN:HTML (Accessed: 22 March 2019).

Space Growth Partnership (2018) *Prosperity from Space*. Available at: http://www.ukspace.org/wp-content/uploads/2018/05/Prosperity-from-Space-strategy_2May2018.pdf (Accessed: 2 February 2019).

Space IGS (2011) *The Space Innovation and Growth Strategy: Main Report*. Available at: https://www.ukspace.org/wp-content/uploads/2019/03/Space-IGS-Main-Report_Feb2010.pdf.

Space IGS (2014) *Space Growth Action Plan*. Available at: https://www.gov.uk/government/publications/space-growth-action-plan.

Space IGS (2015) *UK Space Innovation and Growth Strategy: 2015 Update Report*. Available at: http://www.ukspace.org/wp-content/uploads/2015/07/Space-IGS-Report-Update-July-2015.pdf (Accessed: 31 March 2019).

Space Network Scotland (2017) *Organisational Support for the Space Sector in Scotland*. Available at: https://www.space-network.scot/blog/support-for-the-space-sector.html (Accessed: 10 May 2019).

Spigel, B. (2016) 'Developing and governing entrepreneurial ecosystems: the structure of entrepreneurial support programs in Edinburgh, Scotland', *Int. J. Innovation and Regional Development*, 7(2), pp. 17–19. doi: 10.1504/IJIRD.2016.077889.

Spithoven, A., Clarysse, B. and Knockaert, M. (2010) 'Building absorptive capacity to organise inbound open innovation in traditional industries', *Technovation*. Elsevier, 30(2), pp. 130–141. doi: 10.1016/J.TECHNOVATION.2009.08.004.

Spithoven, A., Vanhaverbeke, W. and Roijakkers, N. (2013) 'Open innovation practices in SMEs and large enterprises', *Small Business Economics*. Springer US, 41(3), pp. 537–562. doi: 10.1007/s11187-012-9453-9.

Spradley, J. (2016) *Participant observation*. Waveland Press. Available at: https://books.google.co.uk/books?hl=en&lr=&id=q7DlCwAAQBAJ&oi=fnd&pg=PR3&dq=participant+observation&ots=H_gjI-QU_4&sig=z44SHwCskwH-ejTVkklh1hiqg9Y (Accessed: 2 April 2019).

Stare, M., Bucar, M. and Udovic, B. (2014) 'Soustvarjanje znanja med javnimi raziskovalnimi organizacijami in gospodarstvom za povecanje konkurencnosti', *IB Revija*, 3–4, pp. 53–59.

Di Stefano, G., Gambardella, A. and Verona, G. (2012) 'Technology push and demand pull perspectives in innovation studies: Current findings and future research directions', *Research Policy*, 41(8), pp. 1283–1295. doi: 10.1016/j.respol.2012.03.021.

Steketee, M., Miyaoka, A. and Spiegelman, M. (2015) 'Social Network Analysis', *International Encyclopedia of the Social & Behavioral Sciences*, pp. 461–467. Available at: http://linkinghub.elsevier.com/retrieve/pii/B978008097086810563X.

Stephens, N. (2007) 'Collecting data from elites and ultra elites: Telephone and face-to-face interviews with macroeconomists', *Qualitative Research*, 7(2), pp. 203–216. doi: 10.1177/1468794107076020.

STFC (2013) *"Higgs Theory 'Gains' Mass!"* Available at: https://www.stfc.ac.uk/2960.aspx.

STFC (2015) *The Higgs Centre for Innovation*. Available at: https://stfc.ukri.org/innovation/campuses/business-incubation/the-higgs-centre-for-innovation/ (Accessed: 15 January 2019).

STFC (2018) *Higgs Centre for Innovation*. Available at: http://www.roe.ac.uk/higgscentre/ (Accessed: 24 December 2018).

Sullivan, F. (2009) *Global Space Industry Stakeholder Mapping. [Stakeholder Report]*. London: Frost and Sullivan.

Summerer, L. (2011) 'Signs of Potentially Disruptive Innovation in the Space Sector', *International Journal of Innovation Science*, 3(3), pp. 127–140. doi: https://doi.org/10.1260/1757-2223.3.3.127.

Sun, P. Y. T. and Anderson, M. H. (2010) 'An examination of the relationship between absorptive capacity and organizational learning, and a proposed integration', *International Journal of Management Reviews*. John Wiley & Sons, Ltd (10.1111), 12(2), pp. 130–150. doi:

10.1111/j.1468-2370.2008.00256.x.

Surrey Satellite Technologies (2019) *About Us - SSTL*. Available at: https://www.sstl.co.uk/about-us (Accessed: 28 March 2019).

Svensson, O. and Nikoleris, A. (2018) 'Structure reconsidered: Towards new foundations of explanatory transitions theory', *Research Policy*. North-Holland, 47(2), pp. 462–473. doi: 10.1016/J.RESPOL.2017.12.007.

Swann, G. M. P. (2009) *The Economics of Innovation: An Introduction*, *2009*. New York: Edward Elgar Publishing. doi: 10.1556/AOecon.60.2010.4.6.

Swartwout, M. (2004) 'University-Class Satellites: From Marginal Utility to "Disruptive" Research Platforms', *AIAA/USU Conference on Small Satellites*. Available at: https://digitalcommons.usu.edu/smallsat/2004/All2004/12 (Accessed: 29 March 2019).

Szajnfarber, Z. (2014) 'Space science innovation: How mission sequencing interacts with technology policy', *Space Policy*. Elsevier, 30(2), pp. 83–90. doi: 10.1016/J.SPACEPOL.2014.03.005.

Tallman, S. *et al.* (2004) 'Knowledge, Clusters, and Competitive Advantage', *Academy of Management Review*, 29(2), pp. 258–271. doi: 10.5465/amr.2004.12736089.

Taylor, D. (2019) *Receiving Meteosat, Metop, AVHRR, ATOVS and more data from the EUMETCast DVB service*. Available at: https://www.satsignal.eu/wxsat/atovs/index.html (Accessed: 29 March 2019).

Tedlock, B. (1991) 'From Participant Observation to the Observation of Participation: The Emergence of Narrative Ethnography', *Journal of Anthropological Research*, 47(1), pp. 69–94. doi: 10.1086/jar.47.1.3630581.

Telespazio (2011) *Telespazio acquires the UK company VEGA Space andthe space activities of Elsag Datamat*. Available at: http://www.telespazio.com/-/telespazio-elsag-vega (Accessed: 28 March 2019).

The Scottish Government (2013) *Scotland Can Do - Becoming a World-leading Entrepreneurial and Innovative Nation*. Available at: http://www.gov.scot/Publications/2013/11/7675/downloads.

The University of Edinbrugh (2002) *Policy on Conflict of Interest*. Edinburgh.

Thomke, S. and Fujimoto, T. (2000) 'The Effect of "Front-Loading" Problem-Solving on Product Development Performance', *Journal of Product Innovation Management*. John Wiley & Sons, Ltd (10.1111), 17(2), pp. 128–142. doi: 10.1111/1540-5885.1720128.

Thomke, S. H. (1998) 'Managing Experimentation in the Design of New Products', *Management Science*, 44(6), pp. 743–762. doi: 10.1287/mnsc.44.6.743.

Thornberg, R. and Charmaz, K. (2012) 'Grounded theory', in Lapan, S. D., Quartaroli, M., and and F. Reimer (eds) *Qualitative research: An introduction to methods and designs*. San Francisco, CA: John Wiley/Jossey–Bass, pp. 41–67.

Tidd, J., Bessant, J. and Pavitt, K. (2005) *Managing innovation: integrating technological, managerial organizational change*. 3rd edn, *New York*. 3rd edn. York: John Wilez and Sons. Available at: https://ir.ucc.edu.gh/jspui/bitstream/123456789/3001/1/%5BJoe_Tidd%2C_John_Bessant%2C_Keith_Pavitt%5D_Managing_In%28BookZZ.org%29.pdf (Accessed: 21 April 2019).

Todorova, G. and Durisin, B. (2007) 'Absorptive capacity: Valuing a reconceptualization', *Academy of Management Review*, 32(3), pp. 774–786. doi: 10.5465/AMR.2007.25275513.

Tontine (2018) *Join Tontine's Space UK Incubator Programme*. Available at: https://www.tontineglasgow.co.uk/Blogs/ViewBlog/36 (Accessed: 11 May 2019).

Von Tunzelmann, N. (2009) 'Competencies versus capabilities: A reassessment', *Economia Politica*, 26(3), pp. 435–464. doi: 10.1428/30999.

Turner, W. *et al.* (2015) 'Free and open-access satellite data are key to biodiversity conservation', *Biological Conservation*. Elsevier, 182, pp. 173–176. doi: 10.1016/J.BIOCON.2014.11.048.

UK Space: The Space Trade Association (2017) 'Leaving the European Union: Space is vital to the UK economy', p. 2. Available at: http://www.ukspace.org/wp-content/uploads/2017/07/Leaving-the-EU-Flyer-May-2017.pdf (Accessed: 31 March 2019).

UK Space Agency (2012) 'Civil Space Strategy 2012-2016', in. Available at: http://www.bis.gov.uk/assets/ukspaceagency/docs/uk-space-agency-civil-space-strategy.pdf.

UK Space Agency (2014a) *Government Response to the UK Space Innovation and Growth Strategy 2014 – 2030: Space Growth Action Plan*. Available at: http://www.ukspace.org/wp-content/uploads/2014/05/Government-Response-Space-Growth-Action-Plan.pdf (Accessed: 31 March 2019).

UK Space Agency (2014b) *UKube-1 - Case study*, *Gov.UK*. Available at: https://www.gov.uk/government/case-studies/ukube-1 (Accessed: 10 May 2019).

UK Space Agency (2015) *UKube-1 completes mission*, *Gov.UK*. Available at: https://www.gov.uk/government/news/ukube-1-completes-mission (Accessed: 10 May 2019).

UK Space Agency (2017) 'New business incubators will help space industry grow'. Available at: https://www.gov.uk/government/news/new-business-incubators-will-help-space-industry-grow (Accessed: 31 March 2019).

UK Space Agency (2018a) *Lockheed Martin and Orbex to launch UK into new space age*. Available at: https://www.gov.uk/government/news/lockheed-martin-and-orbex-to-launch-uk-into-new-space-age (Accessed: 2 February 2019).

UK Space Agency (2018b) 'New laws unlock exciting space era for UK'. Available at: https://www.gov.uk/government/news/new-laws-unlock-exciting-space-era-for-uk (Accessed: 31 March 2019).

UK Space Agency (2019) 'The wider benefits of space investments for the UK economy'. Available at: https://www.gov.uk/government/news/the-wider-benefits-of-space-investments-for-the-uk-economy (Accessed: 31 March 2019).

UK Space Agency provides funding for three new experiments (2018) *Open Access Government* . Available at: https://www.openaccessgovernment.org/uk-space-agency-invests-in-experiments/54695/ (Accessed: 31 March 2019).

Uranjek, E. (2019) *Kaj ima Slovenija od tega, da Evropski vesoljski agenciji plačuje 2,5 milijona evrov letno?*, *MMC RTV SLO*. Available at: https://www.rtvslo.si/znanost-in-tehnologija/kaj-ima-slovenija-od-tega-da-evropski-vesoljski-agenciji-placuje-2-5-milijona-evrov-letno/481004 (Accessed: 31 May 2019).

Urban, G. L. and von Hippel, E. (1988) 'Lead User Analyses for the Development of New Industrial Products', *Management Science*, 34(5), pp. 569–582. doi: 10.1287/mnsc.34.5.569.

Valdaliso, J. M. *et al.* (2014) 'Path dependence in policies supporting smart specialisation strategies Insights from the Basque case', *European Journal of Innovation Management*, 17(4), pp. 390–408. doi: 10.1108/EJIM-12-2013-0136.

Valkokari, K. and Helander, N. (2007) 'Knowledge management in different types of strategic SME networks', *Management Research News*. Emerald Group Publishing Limited, 30(8), pp. 597–608. doi: 10.1108/01409170710773724.

Vanderburg, W. H. (1987) 'Macro-STS: the New Frontier?', *Bulletin of Science, Technology & Society*. Sage PublicationsSage CA: Thousand Oaks, CA, 7(3–4), pp. 700–710. doi: 10.1177/027046768700700344.

Vanhaverbeke, W. and Cloodt, M. (2006) 'Open innovation in value networks', *Open innovation: Researching a new paradigm*, (March), pp. 258–281. doi: 10.1111/j.1467-8691.2008.00502.x.

Vanthillo, T. and Verhetsel, A. (2012) 'Paradigm change in regional policy : towards smart specialisation ? Lessons from Flanders (Belgium)', *Belgeo*. National Committee of Geography of Belgium / Société Royale Belge de Géographie, (1–2). doi: 10.4000/belgeo.7083.

Vasconcelos, A. C. *et al.* (2018) 'Absorptive capacity: A process and structure approach', *Journal of Information Science*, 45(1), pp. 68–83. doi: 10.1177/0165551518775306.

Vasilachis de Gialdino, I. (2011) 'Ontological and Epistemological Foundations of Qualitative Research', *Forum: Qualitative Sozialforschung / Forum: Qualitative Social Research*. Deutsche Forschungsgemeinschaft, 10(2). Available at: http://www.qualitative-research.net/index.php/fqs/article/view/1299/3163#gcit (Accessed: 29 April 2019).

Vasko, C. A. *et al.* (2017) 'Space assets, technology and services in support of energy policy', *Acta Astronautica*. Pergamon, 138, pp. 295–300. doi: 10.1016/J.ACTAASTRO.2017.06.005.

Vass, S. (2013) 'SE aims to help Scots space firms conquer the final frontier: winning funding', *Herald*. Available at: http://www.heraldscotland.com/business/13136391.SE_aims_to_help_Scots_space_firms_conquer_the_final_frontier__winning_funding/.

Velasco, D. (2015) ‘Between Fashion and Storylines of Science, Technology and Inno-vation. Cross-Breeding STS and IS a Process Under Construction’, *EASST Review*, 36(3). Available at: https://easst.net/easst-review/easst-review-volume-34-1-march-2015/between-fashion-and-storylines-of-science-technology-and-innovation-cross-breeding-sts-and-is-a-process-under-construction/.

van De Ven, A. H. and Rorgers, E. M. (1988) ‘Innovations and Organizations’, *Communication Research*. SageNewbury Park, 15(5), pp. 632–651. doi: 10.1177/009365088015005007.

Venturini, K. and Verbano, C. (2014) ‘A systematic review of the Space technology transfer literature: Research synthesis and emerging gaps’, *Space Policy*, 30(2), pp. 98–114. doi: 10.1016/j.spacepol.2014.04.003.

Vidmar, M. (2015) ‘Knowledge Networks at the Heart of Space Industry: The Case of Scotland’, in *13th Reinventing Space Conference*. Oxford, UK, pp. 1–21.

Vidmar, M. (2018) ‘Building a Functional Typology of Innovation Intermediaries’ Interventions’, in *Druid 2018*. Copenhagen: Copenhagen Business School. Available at: https://conference.druid.dk/acc_papers/gpge9gxi0gabcivnep4vgp4ein1cd9.pdf.

Vidmar, M. (2019a) ‘A Multi-level Perspective Geographically-bound Sectoral Systems of Innovation Framework (MLP-GSSI) for Analysing Open Innovation Transition in SMEs’, in *AsSIST-UK National Conference*. Manchester.

Vidmar, M. (2019b) ‘Agile Space Living Lab – The Emergence of a New High-Tech Innovation Paradigm’, *Space Policy*, 49.

Vidmar, M. (2019c) ‘Enablers, Equippers, Shapers and Movers: A Typology of Innovation Intermediaries Interventions and the Development of an Emergent Innovation System’, in *70th International Astronautical Congress*. Washington, D.C.

Vidmar, M. (2019d) ‘The PERIpatetic Approach: On Becoming an Uninformed Insider’.

Vidmar, M. (2019e) ‘The Ten Million Euro Question: How Do Innovation Intermediaries Support Smart Specialization?’, *Croatian Economic Survey*, 21(2), pp. 37–84.

Vidmar, M. *et al.* (2020) ‘New Space and Agile Innovation: Understanding Absorptive Capacity Through Examining Innovation Networks and Moments’, *Acta Astronautica*, 167, pp. 122–134.

Vidmar, M. (2020) ‘New Space and Innovation Policy: Scotland’s Emerging “Space Glen”’, *New Space*, 8(1), pp. 31–51. doi: https://doi.org/10.1089/space.2019.0032.

Vidmar, M., Davies, J. and Patterson, G. (2019) ‘BIS Scotland looks to “reignite its engines”’, *Spaceflight*, p. 47.

Vonortas, N. S. (2002) ‘Building competitive firms: Technology policy initiatives in Latin America’, *Technology in Society*, 24(4), pp. 433–459. doi: 10.1016/S0160-791X(02)00034-9.

Vosburgh, J. A. (1970) ‘Where Does Outer Space Begin’, *American Bar Association Journal*, 56. Available at:

https://heinonline.org/HOL/Page?handle=hein.journals/abaj56&id=136&div=39&collection=journals (Accessed: 30 March 2019).

Voytenko, Y. *et al.* (2016) 'Urban living labs for sustainability and low carbon cities in Europe: Towards a research agenda', *Journal of Cleaner Production*, 123, pp. 45–54. doi: 10.1016/j.jclepro.2015.08.053.

van de Vrande, V. *et al.* (2009) 'Open innovation in SMEs: Trends, motives and management challenges', *Technovation*, 29(6–7), pp. 423–437. doi: 10.1016/j.technovation.2008.10.001.

Wang, J. (2018) 'Innovation and government intervention: A comparison of Singapore and Hong Kong', *Research Policy*, 47(2), pp. 399–412. doi: 10.1016/j.respol.2017.12.008.

Webber, D. (2013) 'Space tourism: Its history, future and importance', *Acta Astronautica*. Pergamon, 92(2), pp. 138–143. doi: 10.1016/j.actaastro.2012.04.038.

Weber, K. M. and Rohracher, H. (2012) 'Legitimizing research, technology and innovation policies for transformative change: Combining insights from innovation systems and multi-level perspective in a comprehensive "failures" framework', *Research Policy*. North-Holland, 41(6), pp. 1037–1047. doi: 10.1016/J.RESPOL.2011.10.015.

Wegener, C. (2014) '"Would you like a cup of coffee?" Using the researcher's insider and outsider positions as a sensitising concept', *Ethnography and Education*. Routledge, 9(2), pp. 153–166. doi: 10.1080/17457823.2013.841082.

Weidenfeld, A. (2013) 'Tourism and cross border regional innovation systems', *Annals of Tourism Research*. Pergamon, 42, pp. 191–213. doi: 10.1016/J.ANNALS.2013.01.003.

Welch, C. *et al.* (2002) 'Corporate elites as informants in qualitative international business research', *International Business Review*, 11(5), pp. 611–628. doi: 10.1016/S0969-5931(02)00039-2.

West, J. *et al.* (2014) 'Open innovation: The next decade', *Research Policy*, 43(5), pp. 805–811. doi: 10.1016/J.RESPOL.2014.03.001.

West, J. and Bogers, M. (2014) 'Leveraging external sources of innovation: A review of research on open innovation', *Journal of Product Innovation Management*, 31(4), pp. 814–831. doi: 10.1111/jpim.12125.

West, J., Vanhaverbeke, W. and Chesbrough, H. (2006) 'Open Innovation: A Research Agenda', in West, J., Vanhaverbeke, W., and Chesbrough, H. (eds) *chesbrough vanhaverbeke & west 2006*. chesbrough vanhaverbeke & west 2006. Available at: https://s3.amazonaws.com/academia.edu.documents/29207878/14.pdf?AWSAccessKeyId=AKIAIWOWYYGZ2Y53UL3A&Expires=1556012001&Signature=J0qrmlGxm7y%2Fn5nGLqtNXpQZAyY%3D&response-content-disposition=inline%3B filename%3DOpen_Innovation_A_Research_Agenda1.pdf (Accessed: 23 April 2019).

Whealan George, K. (2019) 'The Economic Impacts of the Commercial Space Industry', *Space Policy*. Elsevier, 47, pp. 181–186. doi: 10.1016/J.SPACEPOL.2018.12.003.

Why Scotland's tech scene is leading the way (2019) *www.ukstartupjobs.com*. Available at:

https://www.ukstartupjobs.com/career-advice/scotlands-tech-scene-leading-way/ (Accessed: 19 July 2019).

Willetts, D. (2013) *8 Great Technologies*, *2013*. London: Policy Exchange.

Williams, R. (2019) 'Why science and innovation policy needs Science and Technology Studies?', in Canzler, W., Kuhlmann, S., and Simon, D. (eds) *Handbook of Science and Public Policy*.

Williams, R. and Pollock, N. (2009) 'Beyond the ERP implementation study: a new approach to the study of packaged information systems: the biography of artifacts framework', in *ICIS 2009 Proceedings. 6*. Available at: https://aisel.aisnet.org/cgi/viewcontent.cgi?article=1199&context=icis2009 (Accessed: 24 April 2019).

Williams, R. and Pollock, N. (2012) 'Moving beyond the single site implementation study: How (and why) we should study the biography of packaged enterprise solutions', *Information Systems Research*, 23(1), pp. 1–22. doi: 10.1287/isre.1110.0352.

Williams, R. and Velasco, D. (2016) 'How Did We Grow Apart', in *SPRU 50th Anniversary Conference*. Brighton, pp. 1–12.

Wilson, K. (2007) 'Encouraging the Internationalisation of SMEs', in Potter, J. and Proto, A. (eds) *Promoting Entrepreneurship in South East Europe: Policies and Tools*. Paris: OECD, pp. 43–66. Available at: http://www.gvpartners.com/web/pdf/Chapter_2_Wilson_FINAL.pdf (Accessed: 31 May 2019).

Wilson, N. (2019) *Space Spotlight: Scotland is the perfect place to launch your space career*, *Scotland is Now*. Available at: https://www.scotland.org/features/space-spotlight-scotland-is-the-perfect-place-to-launch-your-space (Accessed: 16 July 2019).

Winch, G. M. and Courtney, R. (2007) 'The Organization of Innovation Brokers: An International Review', *Technology Analysis & Strategic Management*. Routledge , 19(6), pp. 747–763. doi: 10.1080/09537320701711223.

Woodcock, C. E. *et al.* (2008) 'Free Access to Landsat Imagery', *Science*. American Association for the Advancement of Science, 320(5879), pp. 1011a-1011a. doi: 10.1126/science.320.5879.1011a.

Wostner, P. (2017) 'From Projects to Transformations: Why Do Only Some Countries and Regions Advance? The Case of the Slovenian S4', *European Structural and Investment Funds Journal*, 5(1), pp. 84–96. Available at: https://estif.lexxion.eu/article/estif/2017/1/11/display/html (Accessed: 30 May 2019).

Wright, M. *et al.* (2015) 'Joining the dots: Building the evidence base for SME growth policy', *International Small Business Journal*. SAGE PublicationsSage UK: London, England, 33(1), pp. 3–11. doi: 10.1177/0266242614558316.

Wright, M., Birley, S. and Mosey, S. (2004) 'Entrepreneurship and University Technology Transfer', *The Journal of Technology Transfer*, 29(3/4), pp. 235–246. doi: 10.1023/B:JOTT.0000034121.02507.f3.

Wulder, M. A. and Coops, N. C. (2014) 'Satellites: Make Earth observations open access', *Nature*, 513(7516), pp. 30–31. doi: 10.1038/513030a.

Wyatt, S. and Balmer, B. (2007) 'Home on the Range: What and Where is the Middle in Science and Technology Studies?', *Science, Technology, & Human Values*. Sage PublicationsSage CA: Los Angeles, CA, 32(6), pp. 619–626. doi: 10.1177/0162243907306085.

Wynarczyk, P., Piperopoulos, P. and McAdam, M. (2013) 'Open innovation in small and medium-sized enterprises: An overview', *International Small Business Journal*. SAGE PublicationsSage UK: London, England, 31(3), pp. 240–255. doi: 10.1177/0266242612472214.

Yin, R. K. (1993) *Applications of case study research*, *Applied social research methods series ;* Available at: https://books.google.co.uk/books?hl=en&lr=&id=FgSV0Y2FleYC&oi=fnd&pg=PP1&dq=yin+case+study&ots=42b4TormQh&sig=eNpMmDaBXWHmU48_mnQ2PlQZMMs#v=onepage&q=yin.

Yin, R. K. (2009) *Case study research*, *Applied Social Research Methods Series*. London: Sage Publishing.

Yin, R. K., Bickman, L. and Rog, D. J. (2009) *Case Study Research: Design and Methods*, *Essential guide to qualitative methods in organizational research*. doi: 10.1097/FCH.0b013e31822dda9e.

Zaheer, A. and Bell, G. G. (2005) 'Benefiting from network position: firm capabilities, structural holes, and performance', *Strategic Management Journal*. John Wiley & Sons, Ltd, 26(9), pp. 809–825. doi: 10.1002/smj.482.

Zahra, S. A. and Filatotchev, I. (2009) 'How do threshold firms sustain corporate entrepreneurship? The role of boards and absorptive capacity', *Journal of Business Venturing*. Elsevier, 24(3), pp. 248–260. doi: 10.1016/J.JBUSVENT.2008.09.001.

Zahra, S. A. and George, G. (2002) 'Absorptive capacity: A review, reconceptualization, and extension', *Academy of Management Review*, 27(2), pp. 185–203. doi: 10.5465/AMR.2002.6587995.

Zeitz, G., Mittal, V. and McAulay, B. (1999) 'Distinguishing adoption and entrenchment of management practices: A framework for analysis', *Organization Studies*, 20(5), pp. 741–776. doi: 10.1177/0170840699205003.

Appendix A: PhD Chapter Structure and Publication Development

Chapter Number	Chapter Objective	Paper Title	Main Points / Content	Target Journal	Progress Status
1	Background, Contextual Overview and Policy Analysis, Scoping Empirical Results	New Space and Innovation Policy - Scotland's Emerging "Space Glen"	• Background review (Space Industry development) • Sectoral, technological and regional characterisation of Space Industry in Scotland • (Innovation) Policy analysis • Scoping interviews about policy, targets and sectoral strengths and weaknesses	New Space	Published
2	Literature Review (1), Scoping and Research Questions	Agile Space Living Lab – The Emergence of a New High-Tech Innovation Paradigm	• Living Laboratory approach to innovation (studies) • The "New" Space Agenda (loose value chain integration as USP for all three characters: region/sector/technology) • Key characteristics to look for: Open innovation, networking, role of non-developers (intermediaries, policy, governance)	Space Policy	Published
3	Literature Review (1) and Empirical Results (1)	New Space and Agile Innovation - Understanding Absorptive Capacity Through Examining Innovation Networks and Moments	• Open innovation and NPD • Absorptive capacity (move from company feature and process to a systemic property) • The conceptual development of "innovation moments" • Ego nets data capture and analysis – expanding network, more public partners, significant divisions (new-classical/up-down stream)	IAC 2018 Acta Astronautica	Presented, draft included in proceedings Published

			• Assembling socio-centric network and identification of key nodes (players) - innovation intermediaries • Changing company structure (hierarchy) • Changing NPD management (project leads)		
4	Literature Review (2)	Innovation Intermediation - Towards a Functional Classification of Interventions	• Redefining "innovation intermediaries" • Focus on Geographically-bound sectoral systems of innovation (GSSI) • Systematic literature review using dividing lines in literature • Shift from organisations/institutions to interventions • (Re-)classification and typology models	Druid 2018 PalgravePivot[45]	Presented, draft included in proceedings Accepted, in preparation
5	Empirical Results (2) and Discussion (2)	Enablers, Equippers, Shapers and Movers - A Typology of Innovation Intermediaries Interventions and the Development of an Emergent Innovation System	• Case studies of Innovation intermediaries in Scotland • Ability to systemically affect innovation – look at establishment processes, place in the innovation network(s) and effects (within NPD) • Deploying classification and typology • Identify intermediaries' roles and effects • Survey of needs and provisions fro different classes of interventions • arguing fro a comprehensive/holistic assessment approach	IAC 2019 Acta Astronautica PalgravePivot	Presented, draft included in proceedings Submitted, in review Accepted, in preparation
6	Empirical Results (2) and Discussion (2)	The 10 Million Euros Question - How Innovation Intermediaries	• Regional economic development policy (smart specialisation) driving the formation of innovation intermediation programmes	smartEIZ 2018	Presented

[45] This refers to a short book proposal (working title "Supporting Emergent Innovation Systems: A Practical Guide to Innovation Intermediation"), combining all innovation intermediation-related papers/chapters (4, 5, and 6). For more details on the Palgrave Pivot format, please see: https://www.palgrave.com/gb/palgrave-pivot

		Support Smart Specialisation?	• Emerging foci of those in innovation intermediaries address R&D and/vs BD challenges • These emerge from political, economic and societal/cultural differences • Different interventions deployed depending on those foci leading to different outcomes • Striving towards more balance	Croatian Economic Survey PalgravePivot	Published Accepted, in preparation

7	Overall Conceptual Framework Discussion	A Multi-level Perspective Geographically-bound Sectoral Systems of Innovation Framework (MLP-GSSI) for Analysing Open Innovation Transition in SMEs	• Merging Interpetivists and normative approaches (innovation studies versus science and technology studies)
			• Integrating Multi-level perspective (MLP) with Sectoral Systems of Innovation (SSI)
			• Foregrounding geographically-bound sectoral systems of innovation (GSSI)
			• Development of analytical framework within three main elements/levels of combined MLP-SSI analysis:
			  ◦ geo-sectoral innovation policy,
			  ◦ Living Laboratories and
			  ◦ absorptive capacity
			and two links between them:
			  ◦ innovation intermediaries' interventions and
			  ◦ innovation moments
				Research Policy	Not yet submitted

8	Overall Methodology and Research Design Discussion	The PERIpatetic Approach - On Becoming an Uninformed Insider	• Abductivism and active participatory research • Biographies of Artefacts and Practices (BOAP)–inspired multi-sited strategic ethnography • Interviewing/embedding in elites • Ethical and practical changes of access, confidentiality of commercially sensitive information and conflict of interest • From "informed outsider" to "uninformed insider" researcher positionality	Qualitative Methods/ Science and Technology Studies	Not yet submitted

Table 17 - Summary of thesis' chapters structure, main points and publication strategy.

Appendix B: PhD Journey

PhD Timeline

Timing	Research Phase 0 = scoping; 1 = research design and literature review; 2 = empirical work; 3 = analysis and feedback; 4 = dissemination	Research Tasks	Chapters/ Papers referring to numbering in Table 17
September 2014-April 2015	Phase 0	Research training and assembling background data (documents), scoping interviews	1, 2
May-August 2015	Phase 0	Pilot: MSc by research dissertation (baseline methodology, literature review and research design; 3 typical case studies of SMEs)	1, 2, 3
September 2015-June 2016	Phase 1	Disseminating pilot results, updating the research framework and research instruments, full-scale introduction to the field, preparing for board review	1, 2, 3
July-October 2016	Phase 2	Corrections to framework from feedback, finalization of the research instruments	2, 3, 4
October 2016-February 2018	Phase 2	Data collection (interviews) in 15 SMEs, preliminary analysis: plotting their Ego-Networks, analyzing NPD-network relationships (some dissemination of results and feedback gathering)	3
August-September 2017	Phase 3	Innovation Caucus Internship on (theoretical) development of innovation intermediation typology	4
January-April 2018	Phase 3	Surveying technology transfer/business development professionals, preliminary analysis: analyzing strategies for network building and direct intervention in companies	5
March-November 2018	Phase 2	Analyzing the Scottish Space Network (i.e. agglomerating Ego-Nets in a complete network map), analyzing key structural components and dissemination of results and feedback	3, 5

Timing	Research Phase 0 = scoping; 1 = research design and literature review; 2 = empirical work; 3 = analysis and feedback; 4 = dissemination	Research Tasks	Chapters/ Papers referring to numbering in Table 17
March 2018-March 2019	Phase 4	Analysis and dissemination of Results to Higgs Centre for Innovation staff (opened in May 2018)	1-6
April-May 2018	Phase 3	Part 1 of the OIV to Slovenia – Empirical Data Collection and Analysis	6
August-October 2018	Phase 4	Part 2 of the OIV to Slovenia – Dissemination	1-6
October 2018-August 2019	Phase 4	Write-Up and Dissemination	1-8

Table 18 - Actual timetable for all completed tasks of my research project; adapted and updated from original research proposal's schedule.

Formal Primary Data Collection

Scoping Interviews – Space and Innovation Policy

Informant	Date	Place	Duration	Notes
Interviewee A	January 2015	Telephone	41 min	
Interviewee B	January 2015	Telephone	42 min	
Interviewee C	July 2017	Royal Observatory Edinburgh (UK)	28 min	
Interviewee D	September 2017	Royal Observatory Edinburgh (UK)	~45 min	Only parts of recording available (due to technical difficulties).
Interviewee E	March 2019	Royal Observatory Edinburgh (UK)	37 min	

Table 19 - Outline of the scoping interviews data collection.

SME Interviews – Innovation Moments and Networks

Informant	Date	Place	Duration	Notes
SME 1 - EU	July 2015	at SME office (UK)	1h 2min	Part of pilot research.
SME 2 - ND	July 2015	at SME office (UK)	1h 27min	Part of pilot research.

SME 3 - CM	August 2015	at SME office (UK)	1h 46min	Part of pilot research.
SME 4 - ND-like	January 2017	at SME office (UK)	1h 45min	
SME 5 - NU-like	January 2017	at SME office (UK)	1h 19min	
SME 6 - NM	February 2017	at SME office (UK)	1h 38min	
SME 7 - CD	February 2017	at SME office (UK)	1h 19min	
SME 8 - ED-like	March 2017	at SME office (UK)	1h 28min	
SME 9 - ND-like	April 2017	at SME office (UK)	54min	
SME 10 - ND-like	May 2017	UK Space Conference, Manchester (UK)	30min	
SME 11 - NU	May 2017	UK Space Conference, Manchester (UK)	54min	
SME 12 - CM-like	May 2017	UK Space Conference, Manchester (UK)	1h 1min	
SME 13 - CM-like	June 2017	UK Space Conference, Manchester (UK)	30min	
SME 14 - EM	June 2017	at SME office (UK)	1h 18min	
SME 15 - ND-like	January 2018	at SME office (UK)	~1h	No recording (refused consent).
SME 16 - NU	February 2018	Data.Space 2018, Glasgow (UK)	1h 14min	
SME 17 - ED	February 2018	at SME office (UK)	1h 22min	

Table 20 - Outline of SNA and qualitative data collection (interviews) among Scottish Space SMEs.

Innovation Intermediaries Detailed Case Studies' Interviews (SNA)

Informant	Date	Place	Duration	Notes
Space.Si	May 2018	Space.Si, Ljubljana (SI)	1h 15min	Full questionnaire (including innovation projects).
Higgs Centre	February 2019	Higgs Centre for Innovation, Edinburgh (UK)	37min	SNA only.

Table 21- Data collection outline for Innovation Intermediaries detailed case studies.

Use, Analysis and Triangulation of Empirical Data

Chapter	Data Sources	Method of Analysis	Triangulation Method
Chapter 1	Scoping Interviews Document Analysis Participant Observation	Narrative Analysis Content Analysis Informal Ethnography	Trend Analysis (Narrative)
Chapter 2	Document Analysis Companies Interviews Participant Observation	Content Analysis Ego-SNA Informal Ethnography	Trend Analysis (Narrative) Case Studies (3 comparative (network) studies + 1 illustrative)
Chapter 3	Companies Interviews	Content Analysis Ego-SNA Composite Socio-centric SNA	Case Studies (9 comparative) Trend Analysis (Structure)
Chapter 5	Intermediaries Survey Document Analysis Companies Interviews Participant Observation	Statistical Analysis Content Analysis Content Analysis Landscape Mapping Composite Socio-centric SNA Informal Ethnography	Case Studies (8 descriptive + 4 comparative) Trend Analysis (Structure)
Chapter 6	Intermediaries Survey Intermediaries Interviews Document Analysis Participant Observation	Statistical Analysis Narrative Analysis Ego-SNA Content Analysis Informal Ethnography	Case Studies (2 comparative)

Table 22 - Outline of uses of data sources, their analysis and triangulation in empirical chapters across the thesis

Appendix C: Scoping Interviews' Guide

1. Your name and professional role (for recording)?
2. What is your relationship/connection to the UK Space Sector, if there is any?
3. What is your relationship/connection to business incubation, entrepreneurship, etc., if there is any?

Space Sector Background

4. What do you know about the "UK Space Programme"?
5. What are the specifics of this programme; comparatively to other space exploration programmes?
6. What do you know about the Space Sector (as an industry sector)?
7. What are the specifics of the Space Sector with respect to other sectors?
8. What are the specifics of the UK Space Sector?

Business Incubation/Start-up (in Space Sector)

9. What are the specifics of business incubation in the UK? And particularly in the Space Sector?
10. In your role, what do you think is the key for the long term success of a (Space) Start-up?
11. What is (are) the key obstacle(s)?
12. Can you share any personal experience of either? Any specific to the Space Sector?
13. What kind of support do you think is needed (would you instigate) to overcome these difficulties and/or ensure the success of an incubation project?
14. There is a UK Government target for 10% of the Space Sector globally to be based in the UK (by 2030). Do you think this is possible or indeed desirable?
15. What is your opinion on the sectoral make-up the Scottish Economy? Do you think it a High-Tech economy?
16. If you were to create a start-up company in Scotland what issues do you think you would be facing, economically, socially or otherwise?
17. How would you overcome these issues?

Long-term (Post-incubation) Issues and Solutions

18. Thinking long term, what issues do you think companies are facing after the incubation/start-up period?
19. Is it any different for a high-tech incubatees (such as Space Sector ones)? (Maybe in terms of spatial location and proximity to (R&D) base?)
20. Do you have any ideas as to how to solve these issues?

Sectoral Systems of innovation as Analysis Tool

21. Have you ever heard of Innovation Systems?
22. There is a tri-partite structure: knowledge flows, institutions and networks of actors. Do you think it is a useful model for analysis of innovation activities?
23. Do you think that High-Tech sectors would fit as an extension to the traditional manufacturing sectors and recent developments in Bio-Tech?

AOB

24. Any last comments?
25. Who else would you recommend we speak to?

Appendix D: SME's Interview Schedule

Background

1. Please, can you give your name and current position?
2. Can you, please, tell me what is your company's name and legal status?
3. Can you please tell me how many people are employed by this company and how many people sit on your board/executive?
4. How old is the company?
5. What is the company's origin (spin-out, start-up, etc)?
6. Can you give me an indication of your company's revenues and profits?
7. Can you please describe your main product (and your key expertise)?

NPD Process Study – "Innovation Moments"

The basic (semi-structured) guide for the qualitative product study is based on the following questions:

1. Please, can you pick two product development processes, whereby one lead to the development of what you would consider your companies' core product and the other was terminated before being ready for entering the market, but was of significant importance to the company.
2. Please, describe these two products.
3. Please, define 5-7 "innovation moments", which you deem crucial for each of the products' design. These can be either
    a. formal key parts of NPD process of a specific product or standardised in your firm
    b. a (disruptive) challenge (either technology or business related) for the project
4. Please, describe in detail each of these "moments" in particular with reference to:
    a. How did you define and analyse the situation/problem?
    b. How were you looking for expertise/past knowledge, experience etc. to understand the problem and seek possible solutions/development ideas?
    c. How did you pick/decide upon the "right" set of solutions and/or synthesised knowledge/expertise?

    d. How did you integrate the solution into the product?

5. Additionally, where did you seek outside expertise in this process? Did you use different experts in different stages of one "innovation moment" (which, when and why)?
6. This information will be the basis of mapping partners/links/connections to specific instances of their involvement in product development, which is also part of the SNA matrix:
7. Partner's Involvement in innovation moments (coded, e.g. P1M1Q1)

Network - SNA

Each of the company's business network constituents will be characterised by:

- Name [to be used only for identification within research]
- Location [precise at least to the categories: same city, Scotland, UK, Europe, Global]
- Age [this information proved impossible to obtain, the objective was to see how many of the members of the network were of similar age; follow up from publicly available sources possible, if needed]
- Size (no. employees) [approximation to "SME", or if other: "small, medium or large"]
- Revenue [this information proved impossible to obtain; follow up from publicly available sources possible, if needed]

The connections will be characterised by[46]:

- Strength:
    - Number of your employees working with the partner?
    - What is this partner's Importance for your Business?
        - rank: 1 (very important) to 5 (low importance)
    - How frequently are you in contact with them?
        - Daily
        - Weekly
        - Bi-weekly
        - Monthly,
        - Quarterly

[46] **Bold** indicates approximate wording of a question.

        - Half-yearly
        - Yearly
        - Occasionally
- Type:
    - What type of partner is this?
        - Academic institution
        - Public body (agency, institution, government department, etc.)
        - Private company,
        - (Independent) Advisor/Agent/Collaborator
        - Other:________________
    - What type of work is this you engage this partner for?
        - R&D (product development)
        - Business Development
        - Marketing (and development of businesses' public interface)
        - Sales
        - Other: ___________________
    - What type of (legal) relationship do you have with your partner?
        - Social (personal relationships)
        - Informal (professional relationships without a legally binding framework, i.e. meetings, discussions, etc.)
        - Contractual (legally binding collaboration with clearly specified rights and obligations for each party)
        - Part/shared ownership (legal incorporation or joint venture)
    - What type of cooperation (i.e. what is the effect of the relationship on your business) do you have?
        - Knowledge acquisition
        - Shared (i.e. "two way" collaboration)
            - research project (i.e. R&D activities)
            - product (and/or patent/license, etc)
            - business model
            - sales (rep)
        - Partnership (open ended "two way" collaboration)

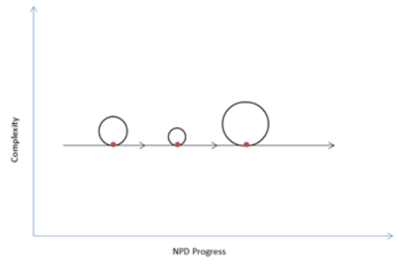
    - Commercial (a formal trade relationship, either as a supplier or customer)
    - Other: ________________________
- Who owns the IP?

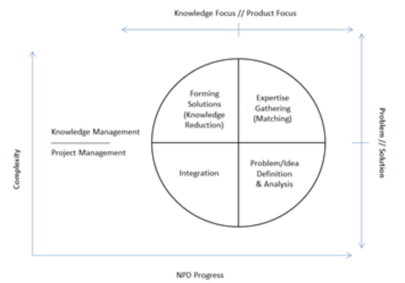
Appendix E: Data Matrix

Biographies of Innovation // Network Analysis

DATA MATRIX - *UK Space & Innovation (MSc Dissertation)* – [Pilot + Key Study]

Interviewee	
Company	
Type (Legal Status)	
Size (no. employees)	
Size of Board/Executive	
Age	
Origin	
Revenues	
Profit	
(Main) Products	
Description?	
Analysed Product 1	
Analysed Product 1	





Product 1: ____

	Innovation Moment 1	Innovation Moment 2	Innovation Moment 3	Innovation Moment 4	Innovation Moment 5	Innovation Moment 6	Innovation Moment 7
Description							
Q1							
Q2							
Q3							
Q4							

Product 2: ____

	Innovation Moment 1	Innovation Moment 2	Innovation Moment 3	Innovation Moment 4	Innovation Moment 5	Innovation Moment 6	Innovation Moment 7
Description							
Q1							
Q2							
Q3							
Q4							

Company	Location	Age of partner	Size of Partner (no. employees)	Revenue	No. of your employees working with the partner	Importance for your Business (rank!)	Frequency of cooperation (D, W, M, Q, H, Y, OCC)	Type of Partner (academic, public institution, private company, advisor…)	Type of Work (R&D, Business, Marketing, Sales…)	Type of relationship (social, informal, contractual, part/shared ownership)	Type of Cooperation (Knowledge acquisition, shared research project/product/business model/sales, commercial or partnership?)	Who Owns IP?	Partner's Involvement in innovation moments (e.g. P1M1Q1)

Appendix F: Intermediaries' Survey Questionnaire

1. Please, briefly (1-2 sentences) describe the innovation intermediation programme/organisation you are/were involved with.

	2. Can you, please, rank these possible intervention priorities areas in order from most important (1) to least important (8) within your programme/organisation?	3. For each of these intervention areas, can you, please, on a scale from 1 to 5 mark whether they are a central part (1) or marginal part (5) of your programme/organisation's provision?	4. Can you, please, rank these possible intervention priorities with respect to where needs are the greatest (1) to least urgent (8) in the whole Scottish Space Industry?
space *i.e. hireable offices at the intermediary-run facilities; hireable rooms for events*			
knowledge *i.e. IP/knowledge generation and distribution; knowledge mapping and database*			

equipment *i.e. hireable facilities; development of new R&D and qualification environments*			
skills *i.e. hireable expertise; formal training; informal experiences; outreach amongst potential recruits*			
interaction *i.e. organisation of, and attendance at, conferences; events; workshop; fora*			
translation *i.e. involvement in, and leadership of, the development of policy (reports), standards; sector promotion to stakeholders, other*			

sectors and the wider public			
<u>work</u> *i.e. work on R&D and commercialisation projects; innovation process management*			
<u>capital</u> *i.e. mobilizing/investing soft and hard capital for R&D and commercialisation projects*			

5. Can you describe briefly (2-3 sentences) why do you think your program/organisation focuses on the areas it does?

6. Can you briefly (2-3 sentences) describe how do you think this focus came about? How was the decision to offer this specific type(s) of intervention(s) made?

7. Could you, please, list all “innovation intermediaries” you can think of, which are operating in the Space Industry in Scotland?

Appendix G: Consent Form[47]

Science & Technology Facilities Council

THE UNIVERSITY OF EDINBURGH

INTERVIEW PARTICIPANT INFORMATION SHEET
"UK/Scottish Space Sector and Innovation"

INVITATION
You are being asked to take part in a research study about the UK/Scottish Space Sector and Innovation. This research is conducted by Matjaz Vidmar, a PhD student in Science, Technology and Innovation student, supervised by Dr Alessandro Rosiello, Dr Niki Vermeulen, Prof Robin Williams and Dr Julian Dines as part of a research partnership between the University of Edinburgh and Science and Technology Facilities Council (STFC).

WHAT WILL HAPPEN
In this study, you will be asked about your views on, experience of, and information about the Space Sector, Innovation and Business Development in the UK and specifically in Scotland.
In particular, you will be asked about new product development (NPD) and innovation at your company and the links and connections to other actors in the sector.
The interview will be audio-recorded and a data-matrix will be filled out.

TIME COMMITMENT
The single interview takes approximately 90-120min.

PARTICIPANTS' RIGHTS
You may decide to stop being a part of the research study at any time without explanation. You have the right to ask that any data you have supplied to that point be withdrawn/destroyed.
You have the right to omit or refuse to answer or respond to any question that is asked of you.
You have the right to have your questions about the procedures answered (unless answering these questions would interfere with the study's outcome). If you have any questions as a result of reading this information sheet, you should ask the researcher before the study begins.
The recording of the interview, and transcription thereof, will be securely stored until the completion of the project upon which it will be destroyed.

BENEFITS AND RISKS
There are no known benefits or risks for you in this study.

COST, REIMBURSEMENT AND COMPENSATION
Your participation in this study is voluntary.

CONFIDENTIALITY/ANONYMITY
We will only collect information about (a) your name, professional role and current position and (b) your contact details. We will only use (b) for the purpose of organising this research, whilst

1/2

[47] The form shown here was used for the core data primary data collection – interviewing SMEs about Innovation Moments and Networks. A similar form with small adjustments (i.e. interview format, aims and duration) was also used when obtaining consent from the scoping interviewees and intermediaries survey participants.

information under (a) might be made public. Please, discuss any concerns you might have regarding that with the researcher. You can choose whether the data under (a) we use in any published material is anonymised or not.

Please, thick this box if you want your personal data to be anonymised: ☐

FOR FURTHER INFORMATION
We will be glad to answer your questions about this study at any time. You may contact us at mvidmar@roe.ac.uk, call +44 (0)131 6688 461, or write to Matjaz Vidmar, Royal Observatory Edinburgh, Blackford Hill, Edinburgh, EH9 3HJ, United Kingdom. You can also contact any of my supervisors – details can be found at www.ed.ac.uk and/or www.stfc.ac.uk.

CONSENT TO PARTICIPATION IN THE RESEARCH
By signing below, you are agreeing that: (1) you have read and understood the Participant Information Sheet, (2) questions about your participation in this study have been answered satisfactorily, (3) you are aware of the potential risks (if any), and (4) you are taking part in this research study voluntarily (without coercion).

____
Participant's Name (Printed)

______________________________	______________________________
Participant's signature	Date
______________________________	______________________________
Name of person obtaining consent (Printed)	Signature of person obtaining consent